PRICE 20/-

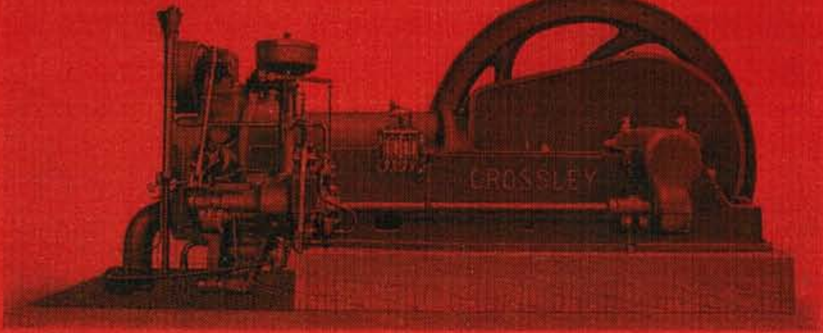
INSTRUCTIONS

FOR

INSTALLING AND OPERATING

CROSSLEY

Four-cycle Horizontal Diesel Engines



CROSSLEY BROTHERS LIMITED

OPENSHAW :: MANCHESTER II :: ENGLAND

INSTRUCTIONS

FOR

INSTALLING AND OPERATING

CROSSLEY

Four-cycle Horizontal Diesel Engines

Single and Double Cylinder Engines, also Monobloc Designs

'HD' 'HH' 'IHD' and 'IHH' types

◆

This Instruction Book applies to Industrial, Electric and Special Electric types commencing on engines of the following sizes :—

HD3 and 0110	Commencing on Engine No. 111600
HD4, IHD4 and 0111	Commencing on Engine No. 110330
HD5 and 0112	Commencing on Engine No. 109880
HD6, HH6, IHD6, IHH6 and 0113	Commencing on Engine No. 110160
HD7, HH7 and IHH7	Commencing on Engine No. 116300
HD8, HH8, IHH8 2HD8 and 0115 and 215	Commencing on Engine No. 80730
HD9, HH9, IHH9, 2HD9 and 0116 and 216	Commencing on Engine No. 91000
HD10, HH10, IHH10, 2HD10 and 0117 and 217	Commencing on Engine No. 80760
HD11, HH11, IHH11, 2HD11, 2HH11, 2IHH11 and 0120 and 220	Commencing on Engine No. 80280
HD12, HH12, IHH12, 2HD12, 2HH12, 2IHH12 and 0121 and 221	Commencing on Engine No. 92220
0122 and 222	Commencing on Engine No. 80820
HD14, HH14, IHH14, 2HD14, 2HH14, 2IHH14 and 0123 and 223	Commencing on Engine No. 80850
HD15, 2HD15 and 0126 and 226	Commencing on Engine No. 80880
0128 and 228	Commencing on Engine No. 78050

◆

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INDEX

TECHNICAL DATA

Summary of principal dimension, clearances, pressures, etc. .. pages 6 to 15

POWER RATING Paragraph

Rating. Deductions for non-standard conditions 1

INSTALLATION

Foundations. Exhaust, Fuel, Water and Starting Air piping .. 2 to 6

ERECTION

Engine erection on site, crankshaft alignment, direct coupling .. 7 to 12

WATER COOLING SYSTEMS

Quality of water and removal of scale .. .. 13 to 15

EXHAUST SYSTEM

Arrangement of pipes 16
Schedule of pipe bores and lengths 17
Exhaust silencers 18

METHOD OF WORKING

Description of cycle 19

INSTRUCTION FOR WORKING

General notes, Insurance and Guarantee .. .. 20 to 22
Log sheets 23
Engine-room and Engineer-in-charge 24
Mechanical and Combustion condition of engine .. .. .. 25 to 27
Exhaust Temperatures and Load 28
Repairs and Spare Parts 29
Critical speeds on double cylinder engines 30
Correspondence 31

PREPARING TO START

Introduction and Procedure .. ..32 and 33

STARTING

Introduction, Starting and After Starting Procedure .. .. .. 34 to 37

STOPPING

Stopping method. Water System and precautions against frost ..38 and 39

AIR AND EXHAUST SYSTEM

Description 40
Exhaust temperatures and correcting dirty Exhaust 41

FUEL SYSTEM

Paragraph
Fuel—quality to use .. 42
Service fuel tank .. 43
Fuel pipes .. 44

FUEL FILTER AND HEATER

Fuel heater and strainer .. 45 and 46
Fuel filter—Felt pad design .. 47
Overflow tundish .. 48

FUEL PUMPS

Description of fuel pumps .. 49 to 53
Fuel pump cam .. 54
Dismantling of fuel pump cam .. 55
Compression and Maximum cylinder pressures .. 56 and 57
Fuel pump valves .. 58
Fuel pump rollers and cams .. 59
Eliminating air from fuel pump .. 60
Testing the fuel pump for "solidity" .. 61
Renewing fuel pump plunger and barrel .. 62
Renewing control valve spindle and guide .. 63
Operation .. 64
Mechanism .. 65
Renewal of joints .. 66

FUEL SPRAYER

Fuel sprayers—general description .. 67 and 68
Testing the spray and cause of dribble .. 69 and 70
Sprayer nozzle .. 71
Sprayer strainer .. 72
Need for cleanliness when dismantling .. 73
Replacing sprayer into breech end .. 74
Leakage past sprayer spindle seating .. 75
Long spindle type sprayers .. 76 to 81
Gland packings for sprayers—long spindle type .. 82
Sprayers of the short spindle type .. 83 to 85

GOVERNOR

Horizontal sideshaft design .. 86 to 88
Vertical pillar design .. 89 to 92

BALANCING THE LOAD—Monobloc engines

Exhaust temperatures and method of ascertaining balance .. 93 to 96

ENGINE CYLINDER

Air silencer and air intake filters 97
Breech end. Air and exhaust valves .. ..98 to 100
Breech end and piston crown clearances 101
Cylinder liner 102
Pistons and piston rings .. .. 103 to 105
Crankshaft main bearings 106
Bearing metals 107
Connecting rod bearings and bolts .. .. 108 and 109
Valve timings 110
Knocking 111
Gearwheels 112
Flywheels and flywheel keys .. .. 113 and 114

COMPRESSED AIR STARTING SYSTEM

Starting apparatus 115
Cam controlled starter valves .. .. 116 to 120
Air receivers, stop valves, and compressed air pipes .. .. 121 and 122
Auxiliary air compressor sets 123

LUBRICATING OIL SYSTEM

Lubrication 124
Mechanical lubricator 125
Lubricating oil—Feed rates and consumption 126
Lubricating oil filter 127

DISMANTLING

Withdrawing pistons 128
Removing air valve body 129
Removing exhaust valve and spring .. .. 130 and 131

INSTRUCTIONS FOR WORKING WITH HEAVY AND VISCOUS FUELS

Description 132
Stopping 133
Fuel strainer 134
Fuel pump cam 135
Viscosity of fuel 136

LIST OF ILLUSTRATIONS

Fig. No.	Description	Page No.
1	Longitudinal and end views of single cylinder engine	16
2	Longitudinal and end views of a monobloc engine	17
3	General installation plan for single cylinder engines	20
4	General installation plan for double cylinder or monobloc engines	21
5	Position of chequer plating or concrete slabs	22
6 and 7	Grouting on single, double cylinder or monobloc engines	22 and 23
8	Exhaust bend and socket	23
9 to 14	Packing plates or wedges for engine bedframe erection	24 and 25
15 to 18	Alignment of crankshaft and bearings	26 and 28
19 to 24	Cooling water circulation systems	29 to 32
25 to 26c	Exhaust pipe systems	35 and 36
27	Cycle of engine operation	38
28	Sectional arrangement and end views of engine	39
29	Fuel tank	55
30 to 32	Fuel pipes for single and double cylinder engines	55 and 56
33	Fuel heater and strainer	57
34	Fuel filter—Felt pad design	58
35	Fuel pump and governor gear on smaller engines with valve design pump	61
36 and 37	Fuel pump—single and double cylinder engines with valve design pump	63 & 64
38 and 39	Fuel pump and setting for a port controlled pump	66 and 67
40	Starting prop for engines with a port controlled pump	67
41	Adjusting of the fuel pump cam and timing	68
42	Control valve	72
43 and 44	Control valve mechanism	73 and 74
45	Sprayer gauges	78
46 and 47	Fuel sprayer—long spindle type	79 and 80
48	Glands for sprayers—long spindle type	81
49 and 50	Fuel sprayer—short spindle combined nozzle design	83
51	Governor—vertical pillar design	86
52	Sectional arrangement of breech end	91
53	Arrangement of oil boat for piston	91
54	Crankshaft and main bearings for monobloc engines	94
55	Connecting rod large-end bolt	97
56	Position of markings on sideshaft and crankshaft gearwheels	98
57	Withdrawing tackle for flywheel	99
58 to 60	Starting air pipe systems	101
61 to 65	Cam controlled and air starter valves	102 to 104
66 and 67	Air receiver stop valves	105
68	Mechanical lubricator—"T. and K." design	108
69 and 70	Lubricating system for single and double cylinder engines	110 and 111
71 to 74	Dismantling of engine	112 and 113
75	Fuel heater for viscous fuels	115
	Inspection and Diagnosis Charts	

TECHNICAL DATA FOR HORIZONTAL FOUR-CYCLE ENGINE

ITEM			Single and Double Cylinder Engines						
			HD4 and IHD 4	HD6 and IHD 6	HH6 and IHH6	HD7, HH7 and IHH 7	HD8, HH8 and IHH 8	HD9, HH9 and IHH 9	HD10, HH10 and IHH 10
ENGINE									
Bore	**HD engines** ..	inches	5·75	6·5	—	7·0	7·75	8·5	9·5
		mm.	146	165	—	178	197	216	241
	HH and IHH engines	inches	5·75	6·5	7·0	7·75	8·5	9·25	10·25
		mm.	146	165	178	197	216	235	260
Stroke		inches	11·0	13·0	13·0	14·0	15·0	16·0	17·0
		mm.	279	330	330	356	381	406	432
* Length of connecting rod between bearing centres		inches	23	25	25	30·0625	34·75	39·75	42·25
		mm.	585	635	635	780	882	1010	1073
Compression ratio	**HD and HH engines** ..		15·4 to 1	15 to 1	16·2 to 1	16 to 1	15·9 to 1	15·6 to 1	15·25 to 1
	IHD and IHH engines ..		13·6 to 1	13·6 to 1	13·6 to 1	13·6 to 1	13·6 to 1	13·6 to 1	13·6 to 1
Compression pressure	**HD and HH engines**	p.s.i.	520	500	550	545	540	525	510
		kg. per cm²	36·6	35·2	38·7	38·3	38	36·9	35·8
	IHD and IHH engines	p.s.i.	450	450	450	450	450	450	450
		kg, per cm²	31·6	31·6	31·6	31·6	31·6	31·6	31·6
Maximum cylinder firing pressure	**HD and HH engines**	p.s.i.	630	630	630	630	630	630	630
		kg. per cm²	44·3	44·3	44·3	44·3	44·3	44·3	44·3
	IHD and IHH engines	p.s.i.	700	700	700	700	700	700	700
		kg. per cm.²	49·2	49·2	49.2	49·2	49·2	49·2	49·2
Compressed air starting system		p.s.i.	250	250	250	250	250	250	250
		kg. per. cm²	17·58	17·58	17·58	17·58	17·58	17·58	17·58
FUEL SYSTEM: (a) Valve design pump									
Bore of plunger barrel	**HD and HH engines**	inch	0·375	0·4375	0·5	0·5625	0·75	0·8125	0·8125
		mm.	9·53	11·11	12·6	14·3	19·05	20·65	20·65
	IHD and IHH engines	inch	0·4375	0·4375	0·5	0·5625	0·8125	0·8125	0·875
		mm.	11·11	11·11	12·6	14·3	20·65	20·65	22·2
Stroke of plunger		inch	0·3125	0·3125	0·3125	0·3125	0·391	0·391	0·391
		mm.	7·94	7·94	7·94	7·94	9·94	9·94	9·94

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* Subject to amendment according to cylinder compression pressure and packing plate thickness between the connecting rod body and large-end bearing

TECHNICAL DATA FOR HORIZONTAL FOUR-CYCLE ENGINE—*contd.*

ITEM **Fuel System**—contd.		Single and Double Cylinder Engines						
		HD 4 and IHD 4	HD 6 and IHD 6	HH 6 and IHH 6	HD 7, HH 7 and IHH 7	HD 8, HH 8 and IHH 8	HD 9, HH 9 and IHH 9	HD10, HH10 and IHH 10
Fuel pump delivery valve lift ..	inch	0·031	0·031	0·031	0·031	0·031	0·031	0·031
	mm.	0·793	0·793	0·793	0·793	0·793	0·793	0·793
(b) Port controlled pump								
Bore of plunger barrel	inch	—	—	—	—	0·75	0·75	0·75
	mm.	—	—	—	—	19·05	19·05	19·05
Stroke of plunger	inch	—	—	—	—	0·5625	0·5625	0·5625
	mm.	—	—	—	—	14·28	14·28	14·28
Fuel pump delivery valve lift ..	inch	—	—	—	—	0·15	0·15	0·15
	mm.	—	—	—	—	3·81	3·81	3·81
Fuel Sprayer			Differential	spring-loaded	spindle type	with multi-hole nozzle		
Lift of Sprayer Spindle — **HD and HH engines**	inch	0·010	0·010	0·010	0·010	0·010	0·010	0·010
	mm.	0·254	0·254	0·254	0·254	0·254	0·254	0·254
Lift of Sprayer Spindle — **IHH engines**	inch	0·018	0·018	0·018	0·018	0·018	0·018	0·018
	mm.	0·457	0·457	0·457	0·457	0·457	0·457	0·457
Sprayer blow-off pressure — **HD and HH engines**	p.s.i. ..	1400	1400	1400	1400	1400	1400	1400
	kg. per cm²	98	98	98	98	98	98	98
Sprayer blow-off pressure — **IHD and IHH engines**	p.s.i. ..	1600	1600	1600	1600	1600	1600	1600
	kg. per cm²	112	112	112	112	112	112	112
ENGINE CLEARANCES								
Clearance between piston crown and breech end	inch	0·110/0·150	0·110/0·150	0·110/0·150	0·110/0·150	0·110/0·150	0·110/0·150	0·110/0·150
	mm.	2·79/3·81	2·79/3·81	2·79/3·81	2·79/3·81	2·79/3·81	2·79/3·81	2·79/3·81
Piston running clearance on diameter at the junk end of piston	inch	0·014	0·019	0·023	0·028	0·032	0·047	0·050
	mm.	0·356	0·482	0·584	0·711	0·813	1·193	1·27
Piston running clearance on diameter at the piston skirt	inch	0·002	0·002	0·0025	0·003	0·003	0·003	0·004
	mm.	0·051	0·051	0·0635	0·076	0·076	0·076	0·102
Clearance between piston ring and groove — Plain full width piston ring	inch	0·003/0·0045	0·002/0·0035	0·002/0·0035	0·0005/0·002	0·0005/0·002	0·0005/0·002	0·0005/0·002
	mm.	0·076/0·114	0·051/0·089	0·051/0·089	0·013/0·051	0·013/0·051	0·013/0·051	0·013/0·051

TECHNICAL DATA FOR HORIZONTAL FOUR-CYCLE ENGINE—*contd.*

ITEM			Single and Double Cylinder Engines						
			HD 4 and IHD 4	HD 6 and IHD 6	HH 6 and IHH 6	HD 7, HH 7 and IHH 7	HD 8, HH 8 and IHH 8	HD 9, HH 9 and IHH 9	HD10,HH10 and IHH 10
Engine Clearances—contd.									
Clearance between piston ring and groove	Plain half width piston ring	inch	—	—	—	0·0005/0·002	0·0005/0·002	0·0005/0·002	0·0005/0·002
		mm.	—	—	—	0·013/0·051	0·013/0·051	0·013/0·051	0·013/0·051
Ring gap when piston is in place	Plain full width piston ring	inch	0·010/0·015	0·010/0·015	0·010/0·015	0·012/0·018	0·012/0·018	0·012/0·018	0·012/0·018
		mm.	0·254/0·38	0·254/0·38	0·254/0·38	0·304/0·457	0·304/0·457	0·304/0·457	0·304/0·457
	Plain half width piston ring	inch	—	—	—	0·012/0·018	0·012/0·018	0·012/0·018	0·012/0·018
		mm.	—	—	—	0·304/0·457	0·304/0·457	0·304/0·457	0·304/0·457
Piston pin diameter	Fixed pin design	inches	2·125	2·375	2·375	2·625	3·0	3·25	3·5
		mm.	54	60·35	60·35	66·7	76·2	82·5	88·8
	Floating pin design	inches	2·5	2·875	2·875	3·25	3·625	3·75	4·125
		mm.	63·5	72·8	72·8	82·5	92	95·2	104·7
Piston pin clearance in piston body	Fixed pin design	inch	0·0015/0·0035	0·0015/0·0035	0·0015/0·0035	0·0015/0·0035	0·0015/0·0035	0·0015/0·0035	0·0015/0·0035
		mm.	0·038/0·089	0·038/0·089	0·038/0·089	0·038/0·089	0·038/0·089	0·038/0·089	0·038/0·089
	Floating pin design	inch	0·001/0·0015	0·001/0·0015	0·001/0·0015	0·001/0·0015	0·001/0·0015	0·001/0·0015	0·001/0·0015
		mm.	0·025/0·038	0·025/0·038	0·025/0·038	0·025/0·038	0·025/0·038	0·025/0·038	0·025/0·038
Piston pin clearance in small-end bush	Fixed pin design	inch	0·002/0·003	0·002/0·003	0·002/0·003	0·002/0·003	0·002/0·003	0·002/0·003	0·002/0·003
		mm.	0·051/0·076	0·051/0·076	0·051/0·076	0·051/0·076	0·051/0·076	0·051/0·076	0·051/0·076
	Floating pin design	inch	0·002/0·003	0·002/0·003	0·002/0·003	0·002/0·003	0·002/0·003	0·002/0·003	0·002/0·003
		mm.	0·051/0·076	0·051/0·076	0·051/0·076	0·051/0·076	0·051/0·076	0·051/0·076	0·051/0·076
Crankshaft main bearing	**HD engines**	inches	3	3·25	—	3·75	3·875	4·25	4·625
	Diameter	mm.	76·2	82·5	—	95·2	98·4	108·0	117·5
	HH and IHH	inches	3·25	3·25	3·75	4·00	4·25	4·625	5·25
	engines	mm.	82·5	82·5	95·2	101·6	108·0	117·5	133·3
	Running clearance	inch	0·005/0·006	0·005/0·006	0·005/0·006	0·005/0·006	0·005/0·006	0·005/0·006	0·005/0·006
		mm.	0·127/0·152	0·127/0·152	0·127/0·152	0·127/0·152	0·127/0·152	0·127/0·152	0·127/0·152
Crankpin or connecting rod large-end bearing	**HD engines**	inches	3·25	3·75	—	3·75	4·625	5·0	5·625
	Diameter	mm.	82·5	95·2	—	95·2	117·5	127·0	142·9
	HH and IHH	inches	3·75	3·75	3·75	4·25	4·625	5·0	5·625
	engines	mm.	95·2	95·2	95·2	108·0	117·5	127·0	142·9
	Running clearance	inch	0·002/0·005	0·002/0·005	0·002/0·005	0·002/0·005	0·002/0·005	0·002/0·005	0·002/0·005
		mm.	0·051/0·127	0·051/0·127	0·051/0·127	0·051/0·127	0·051/0·127	0·051/0·127	0·051/0·127

TECHNICAL DATA FOR HORIZONTAL FOUR-CYCLE ENGINE—*contd.*

ITEM			Single and Double Cylinder Engines						
Engine Clearances—contd.			HD 4 and IHD4	HD 6 and IHD6	HH 6 and IHH6	HD 7, HH 7 and IHH7	HD 8, HH 8 and IHH8	HD 9, HH 9 and IHH9	HD10, HH10 and IHH10
Total axial clearance on crankpin or connecting rod large-end bearing		inch	0·003	0·003	0·003	0·003	0·003	0·003	0·003
		mm.	0·076	0·076	0·076	0·076	0·076	0·076	0·076
Outend bearing	Diameter **HD engines**	inches	2·5	3·0	—	3·125	3·0	3·5	4·0
		mm.	63·5	76·2	—	79·4	76·2	88·8	101·6
	Diameter **HH and IHH engines**	inches	2·5	3·0	3·0	3·0	3·0	3·5	4·0
		mm.	63·5	76·2	76·2	76·2	76·2	88·8	101·6
	Running clearance	inch	0·005/0·006	0·005/0·006	0·005/0·006	0·005/0·006	0·005/0·006	0·005/0·006	0·005/0·006
		mm.	0·127/0·152	0·127/0·152	0·127/0·152	0·127/0·152	0·127/0·152	0·127/0·152	0·127/0·152
Exhaust valve roller clearance	**HD and HH engines**	inch	0·031	0·031	0·031	0·031	0·031	0·031	0·031
		mm.	0·793	0·793	0·793	0·793	0·793	0·793	0·793
	IHD and IHH engines	inch	0·031	0·031	0·031	0·031	0·031	0·031	0·031
		mm.	0·793	0·793	0·793	0·793	0·793	0·793	0·793
Air valve roller clearance	**HD and HH engines**	inch	0·0625	0·0625	0·0625	0·0625	0·0625	0·0625	0·0625
		mm.	1·59	1·59	1·59	1·59	1·59	1·59	1·59
	IHD and IHH engines	inch	0·031	0·031	0·031	0·031	0·0625	0·0625	0·0625
		mm.	0·793	0·793	0·793	0·793	1·59	1·59	1·59
Valve Timings on HD and HH engines in crankshaft degrees—									
Exhaust valve	Opens before Bottom Dead Centre		50 Early	50 Early	50 Early	50 Early	60 Early	60 Early	60 Early
	Closes after Top Dead Centre		20 Late	20 Late	20 Late	20 Late	30 Late	30 Late	30 Late
Air valve	Opens before Top Dead Centre		30 Early	30 Early	30 Early	30 Early	30 Early	30 Early	30 Early
	Closes after Bottom Dead Centre		40 Late	40 Late	40 Late	40 Late	30 Late	30 Late	30 Late
Valve Timings on IHD and IHH engines in crankshaft degrees—									
Exhaust valve	Opens before Bottom Dead Centre		60 Early	60 Early	60 Early	60 Early	60 Early	60 Early	60 Early
	Closes after Top Dead Centre		30 Late	30 Late	30 Late	30 Late	40 Late	40 Late	40 Late
Air valve	Opens before Top Dead Centre		50 Early	50 Early	50 Early	50 Early	50 Early	50 Early	50 Early
	Closes after Bottom Dead Centre		40 Late	40 Late	40 Late	40 Late	30 Late	30 Late	30 Late
Connecting Rod Bolts					See	paragraph No.	109		

TECHNICAL DATA FOR HORIZONTAL FOUR-CYCLE ENGINE—*contd.*

ITEM			Single and Double Cylinder Engines			Monobloc Engines		
			HD 11, HH 11 and IHH 11	HD 12, HH 12 and IHH 12	HD 14, HH 14 and IHH 14	2HH 11 and 2IHH 11	2HH 12 and 2IHH 12	2HH 14 and 2IHH 14
ENGINE								
Bore	**HD engines** ..	inches	11	12·5	14	11	12·5	14
		mm.	279	317	355	279	317	355
	HH and IHH engines	inches	12	13·5	15	12	13.5	15
		mm.	304·8	342·9	381	304·8	342·9	381
Stroke		inches	20	21	23	20	21	23
		mm.	508	533·4	584·2	508	533·4	584·2
* Length of connecting rod between bearing centres		inches	49·375	50·5	58·5	49·375	50·5	58·5
		mm.	1254	1283	1486	1254	1283	1486
Compression ratio	**HH engines** ..		15·25 to 1	14 to 1	14 to 1	15·25 to 1	14 to 1	14 to 1
	IHH engines ..		15·25 to 1	14·1 to 1	14 to 1	15·25 to 1	14·1 to 1	14 to 1
Compression pressure	**HH engines**	p.s.i.	530/550	480/500	480/500	530/550	480/500	480/500
		kg. per cm^2	37·3/38·7	33·7/35·15	33·7/35·15	37·3/38·7	33·7/35·15	33·7/35·15
	IHH engines	p.s.i.	550	500	500	550	500	500
		kg. per cm^2	38·7	35·2	35·2	38·7	35·2	35·2
Maximum cylinder firing pressure	**HH engines**	p.s.i.	700	700	700	700	700	700
		kg. per cm^2	49·2	49·2	49·2	49·2	49·2	49·2
	IHH engines	p.s.i.	700	700	700	700	700	700
		kg. per cm^2	49·2	49·2	49·2	49·2	49·2	49·2
Compressed air starting system		p.s.i.	250	250	250	250	250	250
		kg. per cm^2)	17·58	17·58	17·58	17·58	17·58	17·58
FUEL SYSTEM								
Bore of plunger barrel	**HH engines**	inches	0·875	1	1·0625	0·6875	0.6875	0·8125
		mm.	22·2	25·4	26·98	17·46	17·46	20·64
	IHH engines	inches	1	1·0625	1·125	—	—	—
		mm.	25·4	26·98	28·58	—	—	—
Stroke of plunger		inch	0·406	0·406	0·406	0·6875	0·6875	0·6875
		mm.	10·32	10·32	10·32	17·46	17·46	17·46
Fuel pump delivery valve lift ..		inch	0·034	0·031	0·031	0·0625	0.0625	0·0625
		mm.	0·794	0·794	0·794	1·59	1·59	1·59

* Subject to amendment according to cylinder compression pressure and packing plate thickness between the connecting rod body and large-end bearing

TECHNICAL DATA FOR HORIZONTAL FOUR-CYCLE ENGINE—*contd.*

ITEM		Single and Double Cylinder Engines			Monobloc Engines		
		HD 11, HH 11 and IHH 11	HD 12, HH 12 and IHH 12	HD 14, HH 14 and IHH 14	2HH 11 and 2IHH 11	2HH 12 and 2IHH 12	2HH 14 and 2IHH 14
Fuel System—contd.							
Fuel Sprayer		Differential spring-loaded spindle type with multi-hole nozzle					
Lift of sprayer spindle — **HD and HH engines**	inch	0·010	0·010	0·010	0·010	0·010	0·010
	mm.	0·254	0·254	0·254	0·254	0·254	0·254
Lift of sprayer spindle — **IHH engines**	inch	0·018	0·018	0·018	0·018	0·018	0·018
	mm.	0·457	0·457	0·457	0·457	0·457	0·457
Sprayer blow-off pressure — **HH engines**	p.s.i.	1400/1600	1400/1600	1400/1600	1400/1600	1400/1600	1400/1600
	kg. per cm²	98/112	98/112	98/112	98/112	98/112	98/112
Sprayer blow-off pressure — **IHH engines**	p.s.i.	1600	1600	1600	1600	1600	1600
	kg. per cm²	112	112	112	112	112	112
ENGINE CLEARANCES							
Clearance between piston crown and breech end	inch	0·135/0·145	0·160/0·180	0·165/0·185	0·135/0·145	0·160/0·180	0·165/0·185
	mm.	3·43/3·69	4·06/4·57	4·19/4·7	3·43/3·69	4·06/4·57	4·19/4·7
Piston running clearance on diameter at the junk end of piston	inch	0·074	0·083	0·092	0·074	0·083	0·092
	mm.	1·88	2·1	2·33	1·88	2·1	2·33
Piston running clearance on diameter on the piston skirt	inch	0·006	0·009	0·011	0·006	0·009	0·011
	mm.	0·15	0·23	0·28	0·15	0·23	0·28
Clearance between piston ring and groove — Plain full width piston ring	inch	0·005	0·005	0·005	0·005	0·005	0·005
	mm.	0·127	0·127	0·127	0·127	0·127	0·127
Clearance between piston ring and groove — Plain half width piston ring	inch	0·005	0·005	0·005	0·005	0·005	0·005
	mm.	0·127	0·127	0·127	0·127	0·127	0·127
Clearance between piston ring and groove — ‘ Double seal ’ piston ring	inch	0·006	0·006	0·006	0·006	0·006	0·006
	mm.	0·152	0·152	0·152	0·152	0·152	0·152

TECHNICAL DATA FOR HORIZONTAL FOUR-CYCLE ENGINE—*contd.*

ITEM			Single and Double Cylinder Engines			Monobloc Engines		
			HD 11, HH 11 and IHH 11	HD 12, HH 12 and IHH 12	HD 14, HH 14 and IHH 14	2HH 11 and 2IHH 11	2HH 12 and 2IHH 12	2HH 14 and 2IHH 14
Engine Clearances—contd.								
Ring gap when piston is in place	Plain full width piston ring	inch	0·012/0·018	0·014/0·020	0·017/0·023	0·012/0·018	0·014/0·020	0·017/0·023
		mm.	0·304/0·457	0·355/0·508	0·432/0·584	0·304/0·457	0·355/0·508	0·432/0·584
	Plain half width piston ring	inch	0·012/0·018	0·014/0·020	0·017/0·023	0·012/0·018	0·014/0·020	0·017/0·023
		mm.	0·304/0·457	0·355/0·508	0·432/0·584	0·304/0·457	0·355/0·508	0·432/0·584
	‘ Double seal ’ piston ring	inch	0·039/0·049	0·043/0·053	0·049/0·059	0·039/0·049	0·043/0·053	0·049/0·059
		mm.	0·99/1·25	1·09/1·346	1·25/1·5	0·99/1·25	1·09/1·346	1·25/1·5
Piston pin diameter		inches	4·5	4·75	5·25	4·5	4·75	5·25
		mm.	114·3	120·7	133·4	114·3	120·7	133·4
Piston pin clearance in piston body		inch	0·004	0·004/0·005	0·004/0·005	0·004	0·004/0·005	0·004/0·005
		mm.	0·102	0·102/0·127	0·102/0·127	0·102	0·102/0·127	0·102/0·127
Crankshaft main bearing	Diameter **HD engines**	inches	5·375	6	6·75	5.375	6	6·75
		mm.	136·5	152·4	171·5	136·5	152·4	171·5
	HH and IHH engines	inches	5·75	6·75	7·5	5.75	6·75	7·5
		mm.	146	171·5	190·5	146	171·5	190·5
	Running clearance	inch	0·006	0·007	0·008	0·006	0·007	0·008
		mm.	0·152	0·178	0·203	0·152	0·178	0·203
Crankpin or connecting rod large-end bearing	Diameter	inches	6·625	7·25	8	6·625	7·25	8
		mm.	168	184	203	168	184	203
	Running clearance	inch	0·006	0·007	0·008	0·006	0·007	0·008
		mm.	0·152	0·178	0·203	0·152	0·178	0·203
Total axial clearance on crankpin or connecting rod large-end bearing		inch	0·003	0·003	0·003	0·003	0·003	0·003
		mm.	0·076	0·076	0·076	0·076	0·076	0·076
Outend bearing	Diameter	inches	4·5	5·5	6·5	5·5	6	6·5
		mm.	114·3	139·7	165	139·7	152·4	165
	Running clearance	inch	0·004	0·005	0·006	0·005	0·006	0·006
		mm.	0·102	0·127	0·152	0·127	0·152	0·152

TECHNICAL DATA FOR HORIZONTAL FOUR-CYCLE ENGINE—*contd.*

ITEM			Single and Double Cylinder Engines			Monobloc Engines		
			HD 11, HH 11 and IHH11	HD 12, HH 12 and IHH12	HD 14, HH 14 and IHH14	2HH 11 and 2IHH11	2HH 12 and 2IHH12	2HH 14 and 2IHH14
Engine Clearances—contd.								
Exhaust valve roller clearance	**HH engines**	inch	0·030/0·040	0·030/0·040	0·030/0·040	0·060/0·080	0·060/0·080	0·060/0·080
		mm.	0·762/1·016	0·762/1·016	0·762/1·016	1·524/2·032	1·524/2·032	1·524/2·032
	IHH engines	inch	0·050/0·070	0·050/0·070	0·050/0·070	0·050/0·070	0·050/0·070	0·050/0·070
		mm.	1·27/1·78	1·27/1·78	1·27/1·78	1·27/1·78	1·27/1·78	1·27/1·78
Air valve roller clearance	**HH engines**	inch	0·060/0·080	0·060/0·080	0·060/0·080	0·060/0·080	0·060/0·080	0·060/0·080
		mm.	1·52/2·03	1·52/2·03	1·52/2·03	1·52/2·03	1·52/2·03	1·52/2·03
	IHH engines	inch	0·050/0·070	0·050/0·070	0·050/0·070	0·050/0·070	0·050/0·070	0·050/0·070
		mm.	1·27/1·78	1·27/1·78	1·27/1·78	1·27/1·78	1·27/1·78	1·27/1·78
Valve Timings on HH engines in crankshaft degrees—								
Exhaust valve	Opens before Bottom Dead Centre		55 Early	55 Early	55 Early	57 Early	55 Early	55 Early
	Closes after Top dead Centre		30 Late	30 Late	30 Late	28 Late	30 Late	30 Late
Air valve	Opens before Top Dead Centre		30 Early	30 Early	30 Early	30 Early	30 Early	30 Early
	Closes after Bottom Dead Centre		30 Late	30 Late	30 Late	45 Late	45 Late	45 Late
Valve Timings on IHH engines in crankshaft degrees—								
Exhaust valve	Opens before Bottom Dead Centre		60 Early	60 Early	60 Early	60 Early	60 Early	60 Early
	Closes after Top Dead Centre		70 Late	70 Late	70 Late	70 Late	70 Late	70 Late
Air valve	Opens before Top Dead Centre		60 Early	60 Early	60 Early	60 Early	60 Early	60 Early
	Closes after Bottom Dead Centre		30 Late	30 Late	30 Late	30 Late	30 Late	30 Late
Connecting Rod Bolts			See paragraph No. 109					

RECOMMENDED MAXIMUM WEAR FIGURES OVER AND ABOVE STANDARD RUNNING CLEARANCES, WHEN REPLACEMENT IS ADVISED FOR IMPORTANT OR MAJOR COMPONENTS

Component	Description		MAXIMUM LIMITS						
			Single and Double Cylinder Engines						
			HD 4 and IHD 4	HD 6 and IHD 6	HH 6 and IHH 6	HD 7, HH 7 and IHH 7	HD 8, HH 8 and IHH 8	HD 9, HH 9 and IHH 9	HD10, HH10 and IHH 10
Crankshaft	Crankpin diametrical clearance	inch	0·003/0·005	0·003/0·005	0·003/0·005	0·004/0·006	0·004/0·006	0·005/0·007	0·005/0·007
		mm.	0·078/0·13	0·078/0·13	0·078/0·13	0·10/0·15	0·10/0·15	0·13/0·18	0·13/0·18
	Crankshaft journal clearance	inch	0·004/0·006	0·004/0·006	0·004/0·006	0·004/0·006	0·005/0·007	0·005/0·007	0·005/0·007
		mm.	0·10/0·15	0·10/0·15	0·10/0·15	0·10/0·15	0·13/0·18	0·13/0·18	0·13/0·18
Bearings	Sideshaft bearing	inch	0·008	0·008	0·008	0·008	0·008	0·008	0·008
		mm.	0·2	0·2	0·2	0·2	0·2	0·2	0·2
	Outend bearing clearance	inch	0·003/0·005	0.003/0·005	0·003/0·005	0·003/0·005	0·003/0·005	0·003/0·005	0·003/0·005
		mm.	0·078/0·13	0·078/0·13	0·078/0·13	0·078/0·13	0·078/0·13	0·078/0·13	0·078/0·13
Cylinder Liner	Bore dimension	inch	0·050	0·050	0·050	0·055	0·070	0·075	0·080
		mm.	1·28	1·28	1·28	1·4	1·78	1·92	2·05
Piston	Plain half width piston rings	inch	—	—	—	0·025/0·030	0·025/0·030	0·025/0·030	0·025/0·030
		mm.	—	—	—	0·635/0·762	0·635/0·762	0·635/0·762	0·635/0·762
	Plain full width piston rings	inch	0·025/0·030	0·025/0·030	0·025/0·030	0·025/0·030	0·025/0·030	0·025/0·030	0·025/0·030
		mm.	0·635/0·762	0·635/0·762	0·635/0·762	0·635/0·762	0·635/0·762	0·635/0·762	0·635/0·762

RECOMMENDED MAXIMUM WEAR FIGURES OVER AND ABOVE STANDARD RUNNING CLEARANCE, WHEN REPLACEMENT IS ADVISED FOR IMPORTANT MAJOR COMPONENTS

Component	Description		MAXIMUM LIMITS					
			Single and Double Cylinder Engines			Monobloc Engines		
			HD11, HH11 and IHH 11	HD12, HH12 and IHH 12	HD14, HH14 and IHH 14	2HH11 and 2IHH 11	2HH 12 and 2IHH 12	2HH 14 and 2IHH 14
Crankshaft	Crankpin diametrical clearance	inch	0·006	0·007	0·008	0·006	0·007	0·008
		mm.	0·15	0·18	0·2	0·15	0·18	0·2
	Crankshaft journal clearance	inch	0·006	0·007	0·008	0·006	0·007	0·008
		mm.	0·15	0·18	0·2	0·15	0·18	0·2
Bearings	Sideshaft bearing clearance	inch	0·010	0·010	0·010	0·010	0·010	0·010
		mm.	0·254	0·254	0·254	0·254	0·254	0·254
	Outend bearing clearance	inch	0·005	0·006	0·007	0·005	0·006	0·007
		mm.	0·13	0·15	0·18	0·13	0·15	0·18
Cylinder Liner	Bore dimension	inch	0·085	0·085	0·090	0·085	0·085	0·090
		mm.	2·16	2·16	2·29	2·16	2·16	2·29
Piston	Plain half width piston rings	inch	When clearance between Groove and Ring exceeds 0·025 in. (0·635 mm.) then the groove can be turned and trued up to 0·035 in. (0·9 mm.) and 0·030 in. 0·762 mm.) and oversize rings fitted.					
		mm.						
	Plain full width piston rings	inch						
		mm.						
	'Double seal' piston rings	inch						
		mm.						

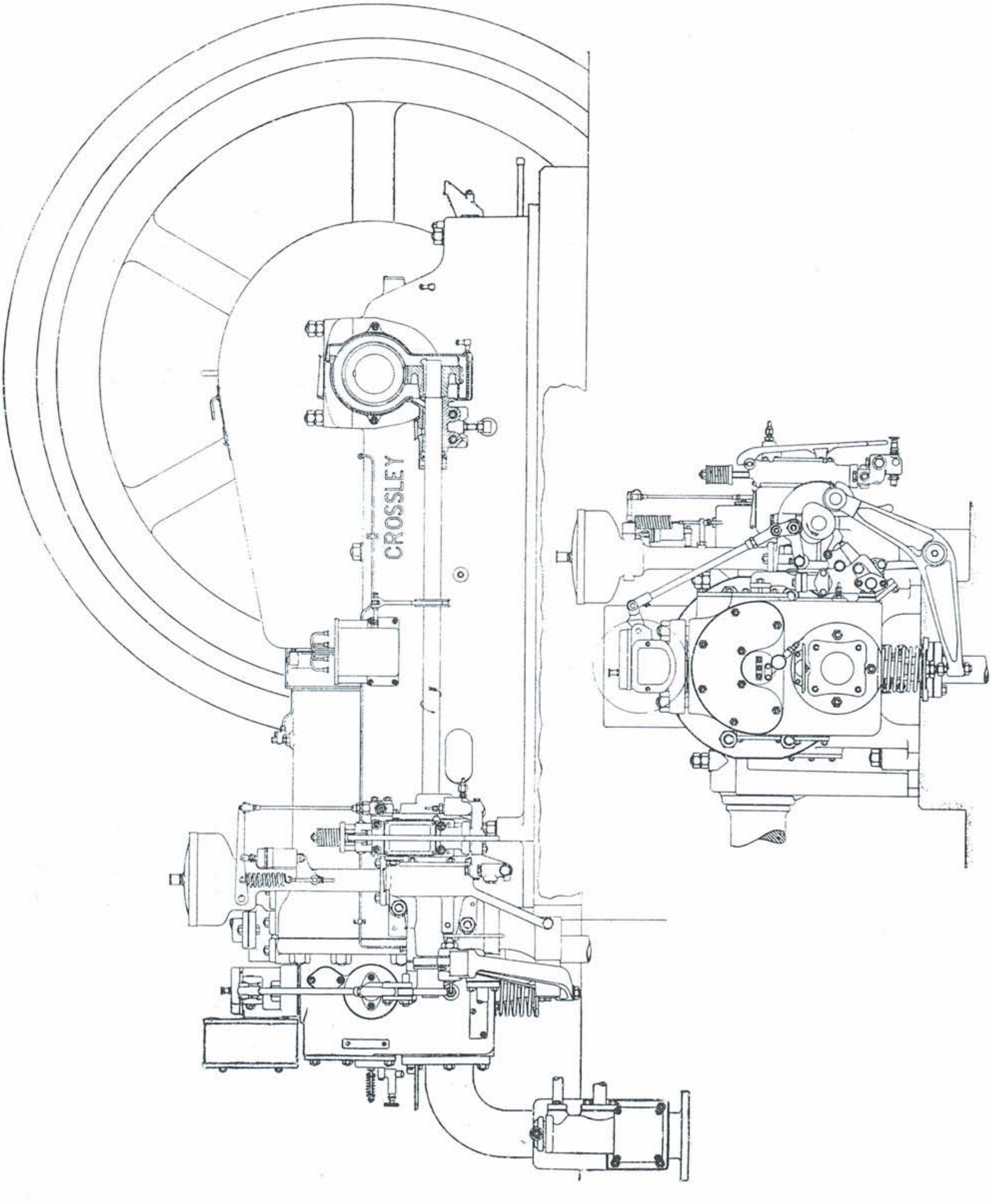


Fig. 1 *Longitudinal and end views of a typical single cylinder engine*

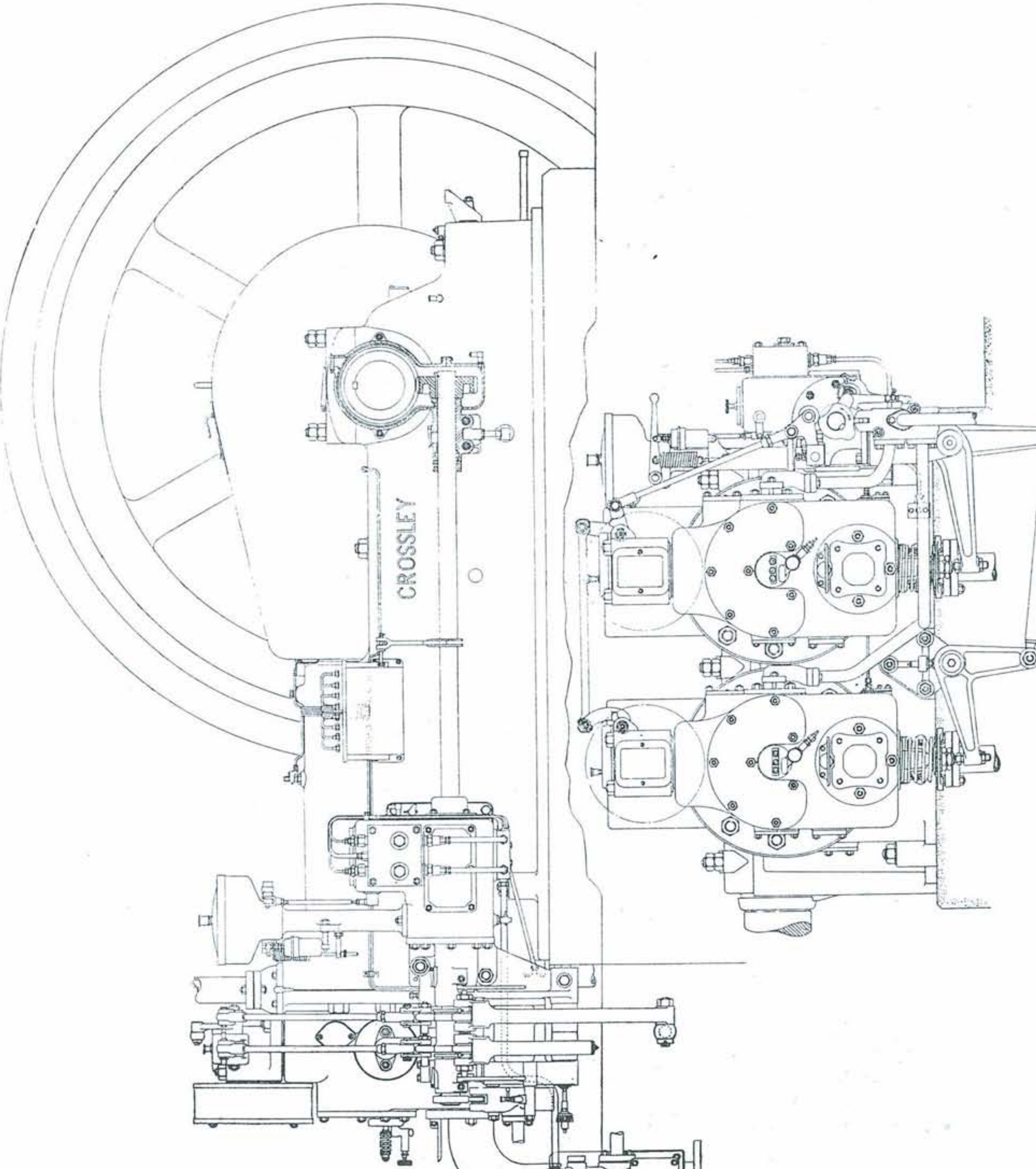


Fig. 2 *Longitudinal and end views of a typical monobloc engine*

POWER RATING

1. The engine generally conforms to British Standard Specification No. 649-1958 and the rated output is the load in Brake Horse Power which the engine is capable of delivering continuously (twenty-four hour rating) at its stated crankshaft speed in revolutions per minute under standard operating conditions of temperature, altitude, humidity etc., as given below and providing the fuel is to British Standards No. 2869 Class "A" specification also that the grade of lubricating oil used is approved by us and provided the engine is maintained in good condition and receives attention in accordance with the recommended schedule of maintenance and overhaul.

When the engine is required to run for long continuous periods between overhauls, and/or on fuels inferior to Class "A", or on lubricating oil different from that approved by us then the normal rated output and maximum power must be the subject of agreement.

Mean barometric pressure ...	29·5 inches (749 m.m.) of mercury corresponding to an altitude of 500 ft. (152 m.) above sea level.
Atmospheric temperature ...	85°F. (29.4°C.).
Humidity	0·6 inches (15 m.m.) of mercury vapour pressure.

To demonstrate the margin of load-carrying capacity the engine is capable of satisfactorily providing an output ten per cent. in excess of the rated output at normal engine speed for one hour in any period of twelve hours consecutive running. **This excess output to be considered as an overload condition.**

Deductions for non-standard conditions:—

(a) For decrease in the atmospheric pressure due to altitude a deduction from the rated output shall be made at the rate of 3.5 per cent. per 1000 ft. (304 m.) as from 500 ft. (152 m.) above sea level.

(b) For an increase in air intake temperature above 85°F. (29·44°C.) a deduction shall be made at the rate of 2 per cent. per 10°F. (5·6°C.).

(c) For humidity a deduction shall be made at the rate of 4 per cent. per inch of mercury (1·6 per cent. per cm. of mercury) of the vapour pressure above 0·6 inches (15 m.m.). The table below gives in convenient form the percentage deduction for humidity alone based on the above specification:—

Humidity Percentage	Atmospheric Temperature								
	85°F.	90°F.	95°F.	100°F.	105°F.	110°F.	115°F.	120°F.	125°F.
	29.4°C.	32.3°C.	35.0°C.	37.8°C.	40.6°C.	43.3°C.	46.1°C.	48.9°C.	51.7°C.
20%	—	—	—	—	—	—	—	0.4	0.8
30%	—	—	—	—	0.3	0.7	1.2	1.7	2.3
40%	—	—	0.2	0.7	1.2	1.8	2.4	3.1	3.9
50%	—	0.4	0.9	1.5	2.1	2.8	3.6	4.5	**5.5**
60%	0.5	1.0	1.6	2.2	3.0	3.8	4.8	**5.9**	7.1
70%	1.0	1.6	2.2	3.0	3.9	4.9	**6.0**	7.3	8.7
80%	1.5	2.2	2.9	3.8	4.8	**5.9**	7.2	8.6	10.2
90%	2.0	2.7	3.6	4.6	**5.7**	6.9	8.4	10.0	11.8
100%	2.4	3.3	4.2	**5.3**	6.6	8.0	9.6	11.4	13.4

The temperature at which the humidity occurs should always be ascertained since it is very rare that high humidity combined with very high temperature is sufficient to justify more than a 6 per cent derating for humidity alone.

INSTALLATION

2. **ARRANGEMENT OF PIPING.**—Diagrammatic engine-house arrangements are shown in Figs. 3 and 4; we consider it desirable that users adhere to these layouts as far as is practicable. The various ancillaries should be arranged so that there is ample working space around the engine; all cocks, strainers, etc., should be readily accessible.

All pipes should be thoroughly cleaned internally before being finally connected. Where possible compressed air should be blown through the pipes to remove all rust or scale, and particular attention should be given to the various filters during initial running-in.

The fuel tank should be placed at the correct minimum height—see paragraph 43.

Compressed air pipes should never be arranged so that condensation drains back into the system—see paragraph 121.

The exhaust piping should be kept reasonably short and should have the minimum number of bends between the engine and the silencer. The exhaust outlet should never be turned into a drain. **Sharp elbows or bends must not be used.** When several bends are necessary, say more than three, or if the system is long or tortuous, the layout must be submitted to us for approval since the total pipe length and its size can seriously affect engine performance by reason of inadequate scavenging of exhaust gases from the combustion chamber.

The pipe bores and lengths recommended for satisfactory engine performance figures are given in paragraph 18.

To allow for expansion the silencer should be placed on iron rollers resting on stone or concrete. On engines where cast iron pipes are used, or when the silencer is immovable, an expansion joint should be inserted in the pipe from engine to silencer. Figs. 8 and 26a.

The exhaust pipe must not be made fast to any wall, **neither must it be placed within 2 feet (0.6 m.) of any timber or inflammable material.** When the exhaust pipe passes through a timbered roof, then the pipe to atmosphere should be protected by asbestos or heat resisting lagging secured with steel wire netting. The roof structure should be cut away and replaced by steel cover plates. Beyond the cover plate a weather cowl is recommended—see paragraph 16 and Fig. 25.

When a water cooling tower is employed, the exhaust outlet to atmosphere should be placed at a sufficient distance away from the tower to prevent the exhaust gases from coming into contact with the water as it trickles down the louvres of the tower. When water is permitted to come into contact with the exhaust gases it takes up acid which can have corrosive effect on the water pipes, and the engine internal parts—see paragraph 13.

Water inlet and outlet pipes should be conveniently arranged according to the cooling system employed—see paragraph 15.

Drain cocks or plugs should be fitted at the lowest point of all exhaust, water and compressed air pipes.

3. **LIFTING THE ENGINE.**—The engine should be lifted by rope slings underneath the bedframe. For dismantling the pistons etc. see paragraphs 128 to 131.

Installation—continued

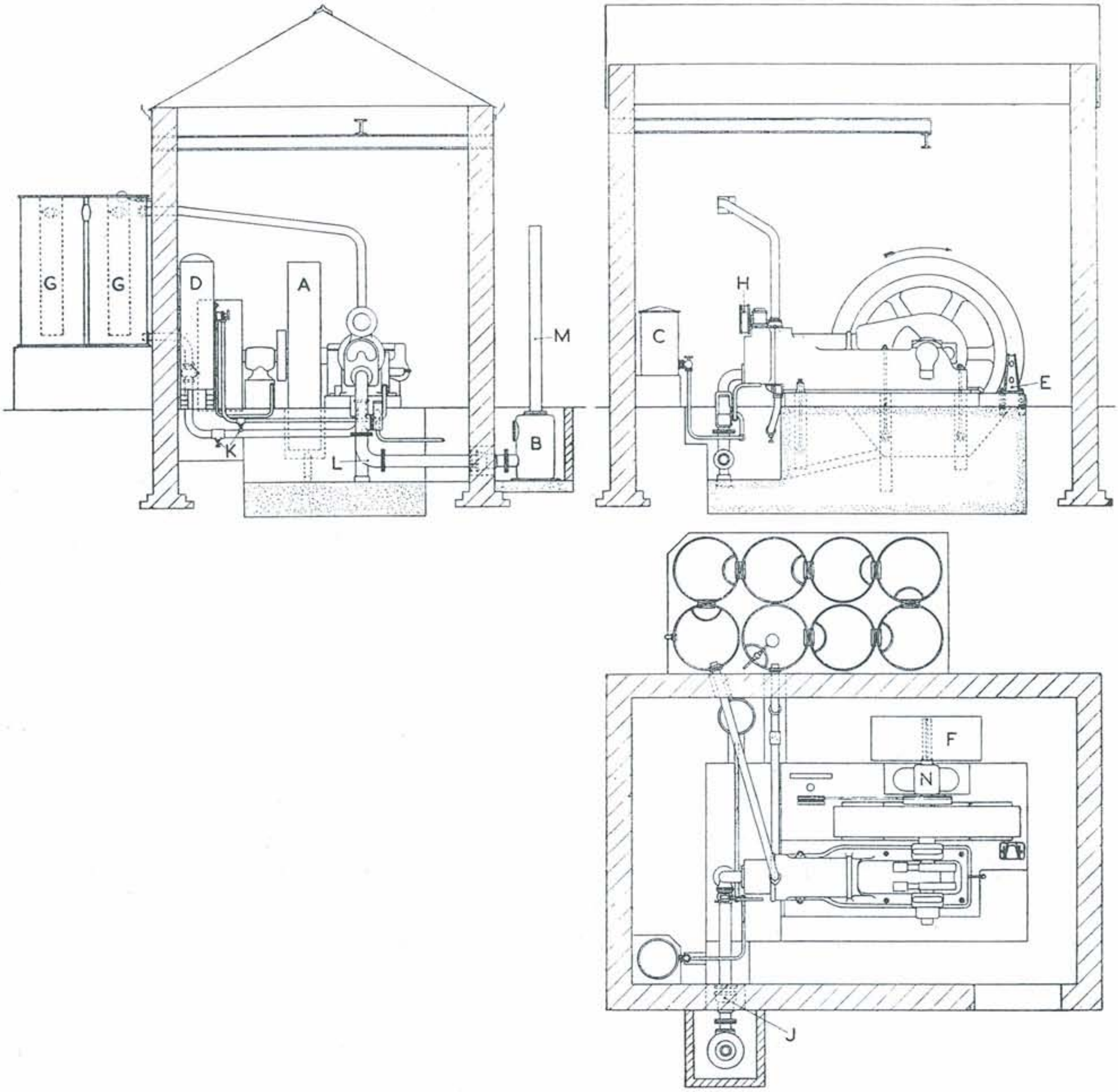
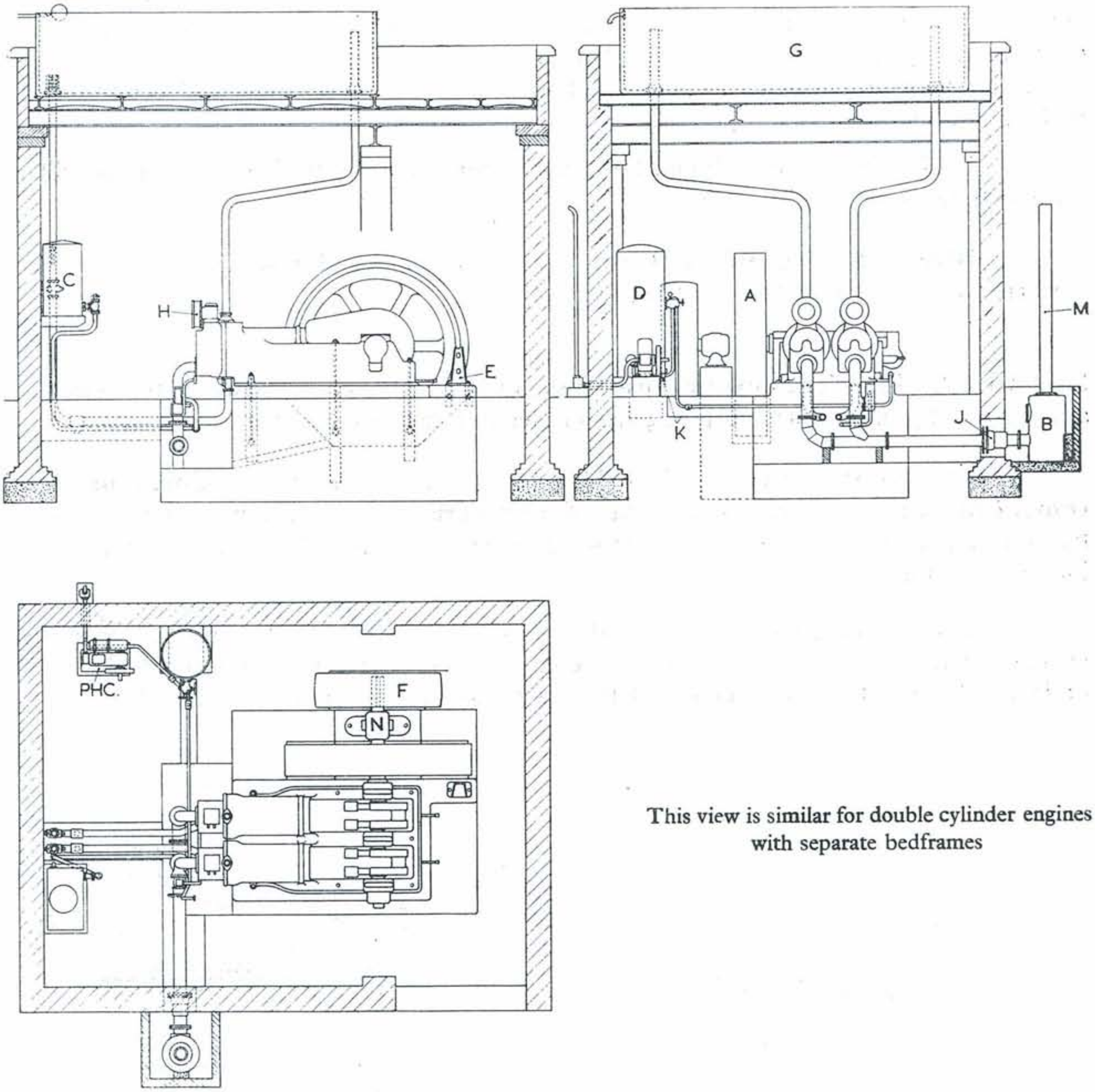


Fig. 3 *General installation plan for single cylinder engines*

(*a*) *Flywheel*
(*b*) *Exhaust silencer*
(*c*) *Fuel tank*
(*d*) *Air receiver*
(*e*) *Barring bracket—when fitted*
(*f*) *Pulley*
(*g*) *Water tanks*

(*h*) *Air silencer*
(*j*) *Expansion socket*
(*k*) *Drain*
(*l*) *Exhaust bend and socket*
(*m*) *Exhaust pipe to atmosphere*
(*n*) *Outend bearing*

INSTALLATION—continued



This view is similar for double cylinder engines with separate bedframes

Fig. 4 *General installation plan for the monobloc engines*

(*a*) *Flywheel*
(*b*) *Exhaust silencer*
(*c*) *Fuel tank*
(*d*) *Air receiver*
(*e*) *Barring bracket*
(*f*) *Pulley*
(*g*) *Water tank*
(*h*) *Air silencers*
(*j*) *Expansion socket*
(*k*) *Drain*
(*m*) *Exhaust pipe to atmosphere*
(*n*) *Outend bearing*
(*PHC*) *Combined engine and compressor*

4. **GENERAL.**—The engine should be erected in accordance with the general arrangement and foundation plans. The foundation must be built on solid ground. Dimensions given on the plans are intended as a general guide and on the assumption the concrete foundation is being built on solid ground; but if the ground is of a yielding nature, the foundation must either be enlarged or a new site found. Where the site lies on a bog-land or water-borne soil, it may be necessary to employ a piled foundation, in which case the conditions need individual attention.

Engine foundations should be isolated from building walls or footings of pillars to prevent transmission of vibration.

Direction of crankshaft rotation.—This is **clockwise** when looking on the flywheel from the sideshaft side of the engine.

5. **CONCRETE.**—The mixture must consist of one part of cement, two parts of clean sharp sand or small granite spar and four parts of clean broken brick or hard stone aggregate.

The size should be ½ inch to 1½ inches (12 mm to 38 mm). **Cheap or inferior cement must not be used.** The quality of the materials used is of importance. Clients must take the responsibility of controlling the work of the contractor when preparing materials and building the foundation.

The top of the foundation should be reasonably level and left rough. Trenches should be lined with bricks or concrete and covered with chequer-plates or slabs, and should be drained. Edges of trenches should be left so as to take the kerbs for chequer-plates.

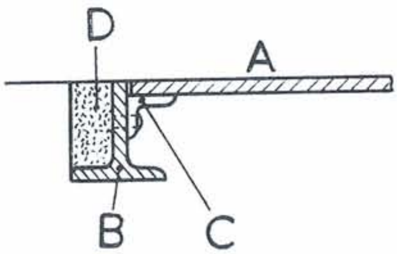


Fig. 5 *Arrangement of chequer plates and support*

(a) Floor level
(b) Tee iron
(e) Angle
(d) Grouting

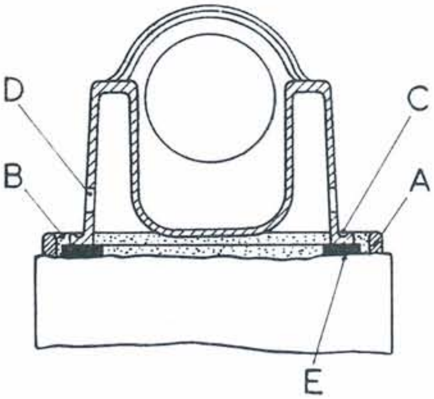


Fig. 6 *Grouting arrangement for single and double cylinder engines*

(a) Clay ridge
(b) Grouting
(c) Oil groove
(d) Grouting holes
(e) Packing plate

A clay ridge A Figs. 6 and 7 should be made round the bedframe, and cement grouting B run in level with the oil groove C from inside through holes D provided. By running the grouting in from the inside of the bedframe, it can be definitely seen whether the grouting has completely filled in the space all round the bedframe. The soleplate under the outend bearing must be grouted up in a similar manner. Use good quality cement for grouting.

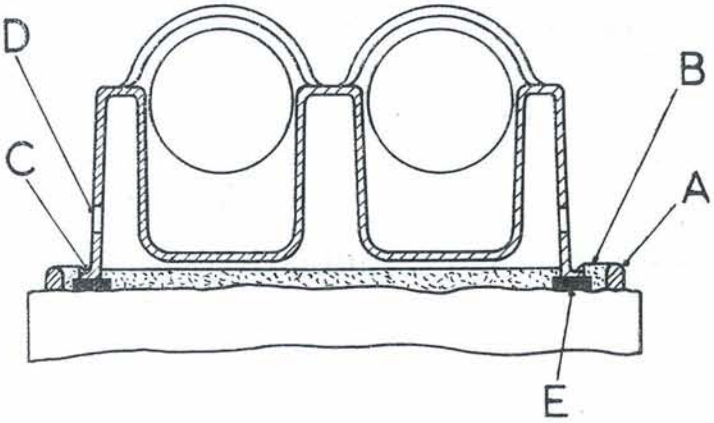


Fig. 7 *Grouting arrangement for monobloc engines*

(*a*) *Clay ridge*
(*b*) *Grouting*
(*c*) *Oil groove*
(*d*) *Grouting holes*
(*e*) *Packing plate*

The groove C round the bedframe is intended to catch oil and prevent it getting on to and rotting the foundation, which can be painted as a further precaution. This oil groove should be cleaned out **daily.**

Where the flywheel race comes below the bedframe level then tubular connecting drains should be laid in the foundation to prevent the accumulation of water or oil lying at the bottom. Drains of this design avoid uncleanliness and protect the concrete foundation.

6. **EXHAUST FOOT BEND.**—Fig. 8.—This is used on installations where the pipes are of cast iron. Provision must be left in the concrete for a guide socket B and for this to be secured in place with cement grouting when the pipe bend A has finally been placed in position.

The setscrews in the socket B must be fitted so they just touch the foot on the exhaust bend A, but no pressure must be exerted on this bend. This arrangement allows the exhaust bend to expand vertically and will prevent any strain being put on the breech end. On monobloc engines a combined fabricated steel or cast iron junction piece is used which is supported on either a concrete or brick pier in the exhaust pipe trench. Expansion of the horizontal pipe is accommodated by the inserting of an expansion socket J, Figs. 3 and 4, and socket D, Fig. 26a. The gland is packed with asbestos cord packing.

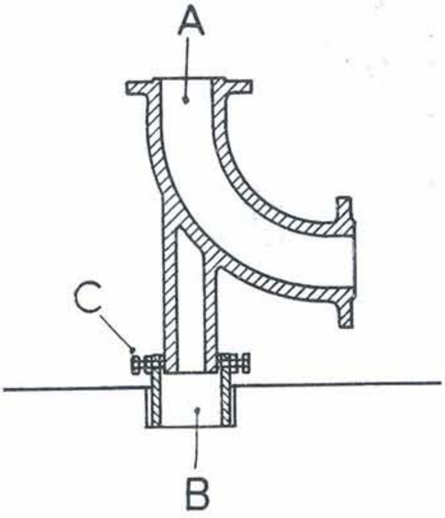


Fig. 8

Exhaust Foot Bend and Guide Socket

(*a*) *Exhaust foot bend*
(*b*) *Guide socket*
(*c*) *Locating screws*

ERECTION

7. **OWNER.**—Before the Owner or "Engineer-in-Charge" accepts an engine, he should satisfy himself that the notes on the foundation and erection plan have been duly observed during the installation. When unpacking the engine care must be taken to prevent damage.

8. **PACKING PLATES AND WEDGES FOR ENGINE ERECTION.**—Figs. 9 to 12 show the recommended positioning of the steel packing plates or wedges; the quantity shown must be taken as a minimum requirement.

Where an outend bearing is employed it is advisable to place plates or wedges under the central portion of the soleplate, in addition to those at each side of the foundation bolt.

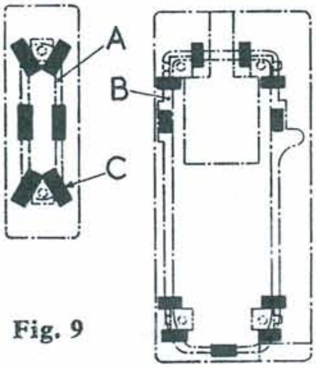


Fig. 9

IHD/IHH 4 to 7 engines

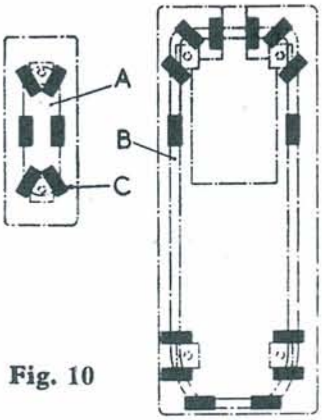


Fig. 10

IHH 8 and 9 engines

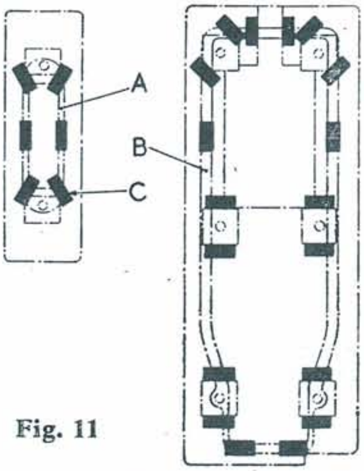


Fig. 11

IHH 10 engine

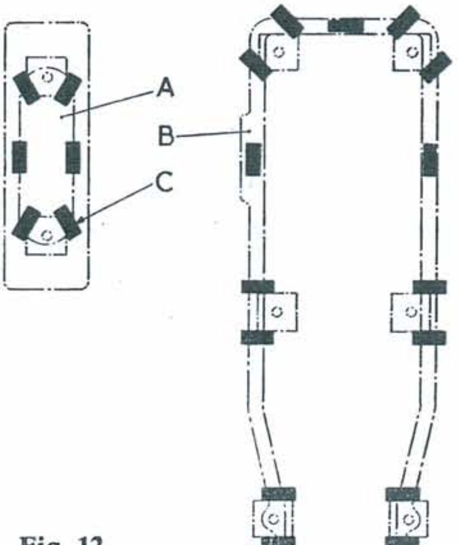
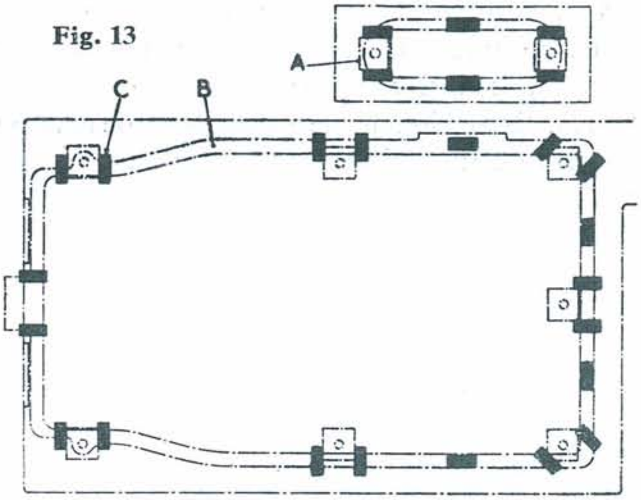


Fig. 12

IHH 11 to 14 engines

Fig. 13



Monobloc engines

(*a*) *Outend Bearing* (*b*) *Bedframe* (*c*) *Packing Plates or Wedges*

The positioning of packing plates or wedges shown above are also applicable to the HD and HH range of engines.

Care must be taken to ascertain the plates or wedges lie firmly on the concrete and that those under the crankshaft bearing have not been omitted.

An engine should be arranged so that the breech end is slightly higher than the crankshaft end; this is to facilitate oil drainage from the cylinder. A slope of $\frac{1}{16}$ inch per foot (1 mm. per 200 mm.) is recommended.

Level up the engine and outend bearing in both directions; use thin shims on the packing plates for further adjustments.

9. PACKING WEDGES AND BLOCKS—Figs. 13 and 14—method of application.

These are provided to enable the erector to make a solid contact between the bedframe and the hard foundation, without using shims; the procedure recommended is:—

(a) Mark out the position of the slide blocks A on the foundation.

(b) Chip away any thin layer of cement and firmly bed the blocks on to the concrete.

(c) Place the block A and wedges in position, and with the aid of a spirit level and straight edge, level up as many of the blocks as possible without using packings. It may be found that, owing to an uneven foundation, a block is too low, then a steel packing B should be inserted between the foundation and the block A; packings of varying thickness are provided. Layers of cement must not be used under the blocks to facilitate levelling.

When finally levelling the bedframe D, it is found that a block A is low and out of range of the wedge C, then a thicker packing B should be inserted under the block.

(d) When the erection is completed, the pegs E in the blocks A should be tack welded to the wedges G.

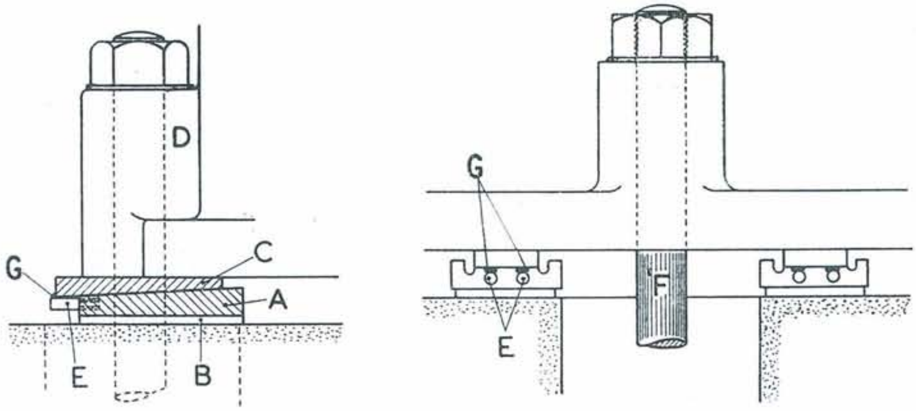


Fig. 14

(a) Slide block
(b) Packing plate
(c) Wedge
(d) Bedframe
(e) Peg
(f) Bedframe bolt
(g) Tack weld when finally positioned

10. **GROUTING IN FOUNDATION BOLTS.**—Mix liquid grout consisting of two parts of sharp sand, or finely granulated hard flint or granite, to one part of cement made sufficiently fluid to pour into the holes in the concrete. Time must be allowed for the grouting to set, and it is important that in the first instance the foundation bolts only are grouted in.

11. **ALIGNMENT—Crankshaft.**—When the balance weights are packed separately from the crankshaft they should be carefully fixed by a competent engineer. When the nuts have been screwed up tightly they should be pinned in position, and the split pins opened out.

Care must be taken to ascertain oil holes through the crankshaft are free from obstruction, although the outlets may be temporarily sealed on arrival. The oil passages should be cleaned with a wire brush; a magnetic rod can also be employed.

Before checking the alignment it is important the outend bearing is bedded to the crankshaft in its final position on site, to ensure cool running.

All bearings must be perfectly in line; over-heating of the bearings is frequently an indication they are out of line, and should be attended to immediately, see paragraph 104. When checking the alignment, keep the bearing caps in position so as to obtain results under working conditions, and examine the crankshaft deflection with a micrometer.

(1) **With an inside Micrometer:—**

- (a) Measure the distance between the crankshaft webs, first with the crankpin in its **top** position, and second with it in its **bottom** position, Fig. 15. In order to place the micrometer in the same position at each operation, mark the place in the middle of the web and about 0·25 inch (7 mm.) from the edge as at X.
- (b) Note the difference between the measurements taken in both positions, and if the distance is greater when the crankpin is at the top than when it is at the bottom, either the bearing B is too low or the bearing C is too high.
- (c) If the distance between the webs is greater with the crankpin at the bottom, Fig. 16, the bearing C is too low.

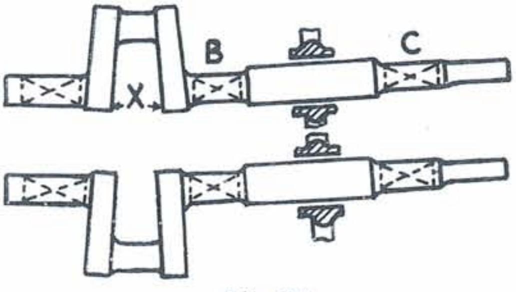


Fig. 15

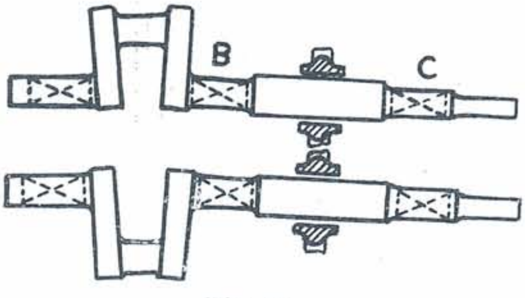


Fig. 16

(2) **With a dial Micrometer:—**

- (d) Turn the crankshaft so that the crankpin is in its lowest position and insert the indicator between the crankshaft webs or balance weights, so that the face of the gauge is towards the engine cylinder.

(e) Use a suitable lengthening bar and screw out the adjusting nut on the base until there is sufficient pressure to maintain the indicator in position. The nut should be screwed up until the pointer of the gauge reads at zero.

(f) Rotate the crankshaft half a revolution with the crankpin moving towards the engine cylinder, and read off the figures given on the dial. The indicator must not be disturbed during this operation, if necessary the connecting rod large-end bearing should be dismantled.

(g) When it is necessary to check the alignment in a horizontal direction, the readings should be taken in the "IN" and "OUT" positions of the crankshaft, instead of vertically and horizontally. The indicator should be placed in such a position as to allow a full half turn of the crankshaft without disturbing the indicator.

The permissible difference should not exceed 0.002 in. (0.05 mm.), when measured at the point X, Fig. 15.

Correct alignment is important and should be re-checked after the engine has been running for a short time under service conditions and therefore periodically as a safeguard against possible movement of the outer bearing.

On engines fitted with two flywheels the wheel on the side opposite to the sideshaft is driven up against a shoulder on the crankshaft; this determines the correct end clearance in the main bearing.

12. **ALIGNMENT—Crankshaft Main Bearings on Monobloc Engines.**—Fig. 17. To avoid distorting the bedframe casting, the positions in the bearing housings A, B and C should be checked before and after tightening the engine foundation bolts.

A point gauge is supplied to facilitate checking and the gauge should be used within the mark "X" on the bedframe bearing housing.

The erector will notice that the gauge is 0.005 in. (0.127 mm.) short, therefore a feeler of 0.005 in. (0.127 mm.) thickness must be inserted to give the correct gap measurement.

Checking the level with a straight-edge on faces E, F and G will be found a good guide when installing.

The "bedding" and the crankshaft alignment will be the final check, but it is usually found that the level checked with a straight-edge will be within 0.004 in. (0.102 mm.).

The correct method of obtaining the correct amount of "nip" in the crankshaft main bearing of monobloc engines is:—

(a) Fit a 0.025 in. (0.635 mm.) brass liner W Fig. 18 at both faces X and 0.0625 in. diameter (1·587 mm.) lead wire Z along the joint faces of the bearing at point Y.

(b) Tighten the main bearing cap bolts down until the caps are down "solid."

(c) Remove bearing cap and measure the thickness of the lead wire Z.

(d) The correct "nip" is obtained when thickness of the lead is 0.020 to 0.022 in. (0·51 to 0·56 mm.). The brass liners should be removed.

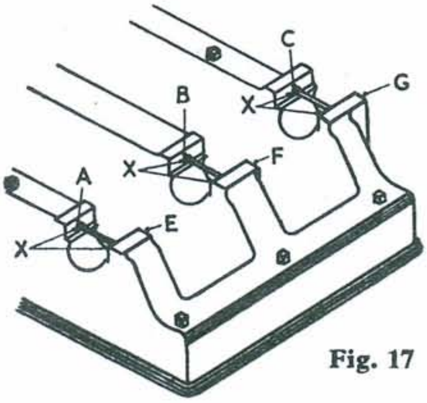


Fig. 17

(a) Bearing housing
(b) Bearing housing
(c) Bearing housing
(e) Bearing housing face
(f) Bearing housing face
(g) Bearing housing face
(x) Bearing housing faces for point gauge

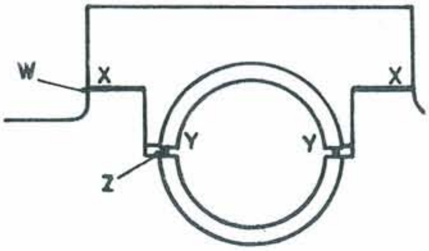


Fig. 18

(w) Brass liner
(x) Bearing face
(y) Bearing joint face
(z) Lead wire

Correct alignment is important and should be re-checked after the engine has been running a short time, and periodically afterwards as a safeguard against possible subsidence of the outer bearing.

WATER COOLING SYSTEMS

13. **CIRCULATING WATER TANK AND PIPES.**—Water tanks may be sent out fitted with internal partitions or nested together. When sent out "nested" the internal partitions are bent to shape and sent loose, except on the inner tank.

The arrangement of partitions to aid cooling, must be arranged as shown on the foundation plan. Tanks must be supported under the whole of the bottom surface, otherwise the weight on the unsupported bottom plate will cause leakage and the bottom of the tanks should not be lower than the centre line of the cylinder.

In hot countries the water vessel capacity must be increased to suit the climate; double the normal capacity is recommended. For night and day running in any climate a further increase may be necessary. One large tank is used on the larger engines. A ball tap must be fitted to the cold water supply pipe.

Pipes must be arranged so that the inlet for cold water is connected to the bottom of one tank and the outlet for hot water connected to the top of another tank. The outlet pipe from the engine must slope upwards at every point; sharp elbows or bends must not be used. A stop cock and drain tap are placed in the inlet pipe, and are used when the cylinder requires draining.

Water systems where an uninterrupted supply is available

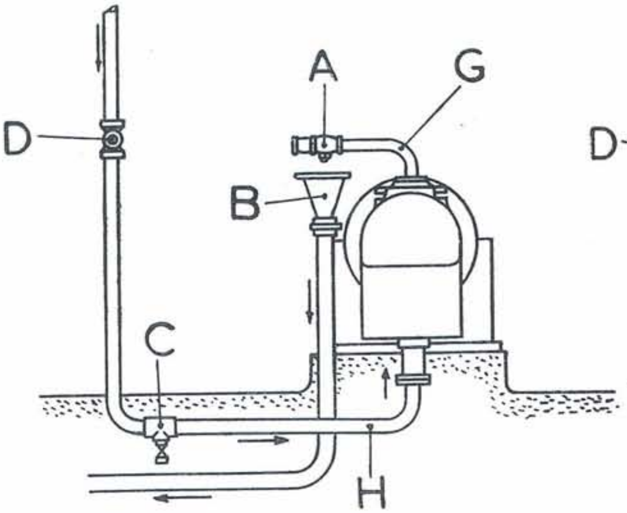


Fig. 19 *Single cylinder engines*

(*a*) *Outlet water cocks*
(*b*) *Tundish*
(*c*) *Drain*

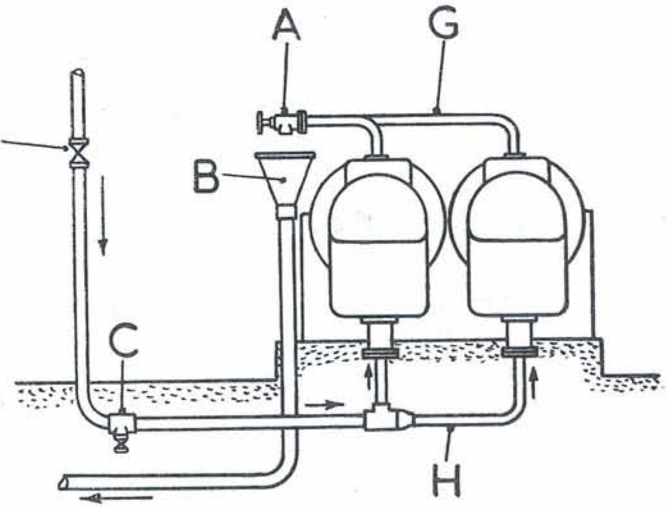


Fig. 20 *Double cylinder and monobloc engines*

(*d*) *Stop cock on inlet water pipe*
(*g*) *Outlet water pipes from engine*
(*h*) *Inlet water pipes to engine*

Water systems incorporating an overhead safety tank with run-through circulation

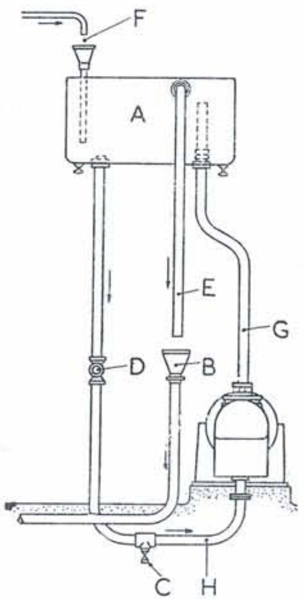


Fig. 21 *Single cylinder engines*

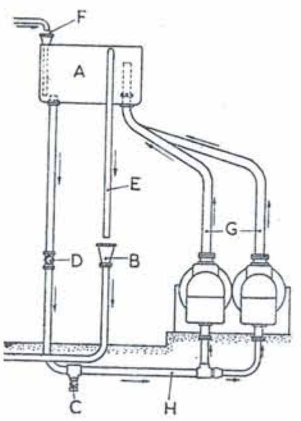


Fig. 22 *Double cylinder and monobloc engines*

(*a*) *Overhead safety water tank*
(*b*) *Tundish*
(*c*) *Drain*
(*d*) *Stop cock on inlet water pipe*
(*e*) *Overflow pipe*
(*f*) *Visible supply from pressure main or pump*
(*g*) *Outlet water pipe from engine*
(*h*) *Inlet water pipe to engine*

14. **QUALITY OF CIRCULATING WATER AND REMOVAL OF SCALE.**—Clear rain water is the best or soft water from a town supply. Hard water should be treated to a non-scaleable degree to avoid deposits in the water passages.

When deposits in the water spaces are difficult to scrape off, their removal may be facilitated by the use of suitable solvents, when it can then be washed away or softened sufficiently to be scraped off. Commercial hydrochloric acid (spirits of salts) is a suitable solvent when used in the proportions one part acid to three parts of water.

After stopping the engine, drain all the water from the jackets and fill up with the diluted acid solution. Leave this in for a night or so. A stronger solution can be employed if the scale deposit is not removed.

After using scale solvents it is important that all water passages are thoroughly washed so as to prevent any acid attacking the metal.

After removing scale, it is important that no deposits are left in the water pipes which would obstruct the free flow of water. All pipes should be cleaned before the engine is restarted.

When scale formation is excessive, it is advisable to use either a better source of water supply, or to soften the water before use by a proprietary softener or compound such as "D.M. Boiler Solution" manufactured by Messrs. Houseman & Thompson Ltd., Newcastle-upon-tyne. We shall be pleased to give advice on the use of suitable solvents on receipt of a sample of the deposit.

With "hard" water it may be advisable to use larger tanks to obviate the necessity of using make-up water. With impure water the tanks should be cleaned out frequently.

When the scale is allowed to increase it will lead to either the fracture of the insufficiently cooled parts or excessive wear on moving parts.

15. **WATER SYSTEMS.** (a) **Tank Circulation.**—This is much the best and safest method. Keep the water level high enough to cover the return pipe from the cylinder by at least 2 ins. (51 mm.), but not high enough to cover the pockets in the tanks. See the ball tap is operating, and that the surface of water is 3 ins. (72 mm.) from the top. When an engine operates continuously, some cold water should be run in by holding the ball tap down and running out water through the overflow pipe.

Withdrawal of the water from the Cylinder Jackets.—To do this, the ball tap must **first be propped up,** the stop cock on the inlet water pipe closed, and the drain tap opened. The water will drain from the outflow pipe and jacket, without emptying the water tank. Take care before restarting the engine to see that the stop cock is opened, the drain tap closed, and that the ball tap is released and works freely.

(b) **Run-Through Circulation.**—Clean "soft" water is the best because it contains no scale forming salts. When arranged for run-through or pumping through the jackets to waste, it is advisable to have separate inlet supplies to the cylinder and breech end with independent outlet regulator cocks from the top of the engine. The **main cock on the water inlet pipe must not be used** for regulating the supply.

Should the engine become overheated at any time, it must not be cooled suddenly by passing cold water through it, the load must be reduced until the temperature is normal.

It is important with the " run-through " system that the engine be allowed to run at no load for five or ten minutes before stopping, so as to cool down slowly, or it may be stopped and the amount of water regulated by hand to prevent too rapid cooling, sudden cooling may result in fracture of the breech end. When the water supply is shut off suddenly the heat stored in the metal will quickly raise the water temperature to boiling point. The safety tank system is recommended where there is a likelihood of the water supply being interrupted.

Water systems with single vertical safety tank with run-through circulation

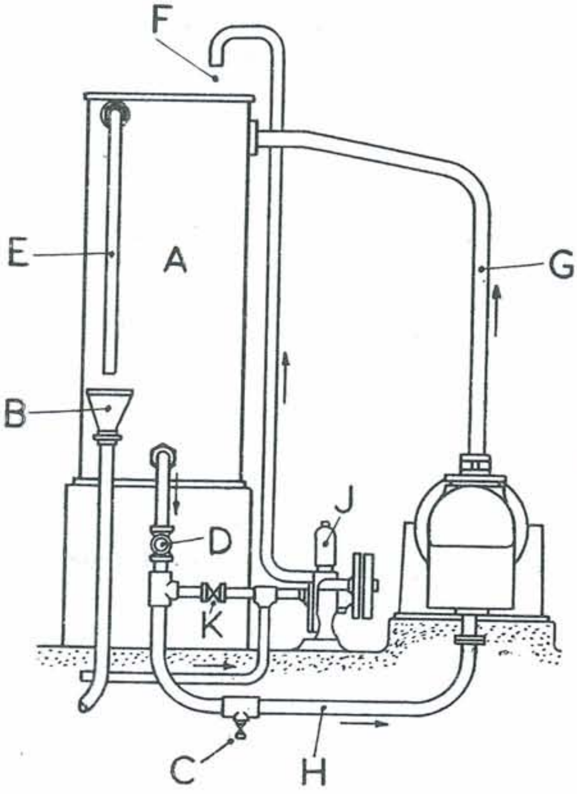


Fig. 23 *Single cylinder engines*

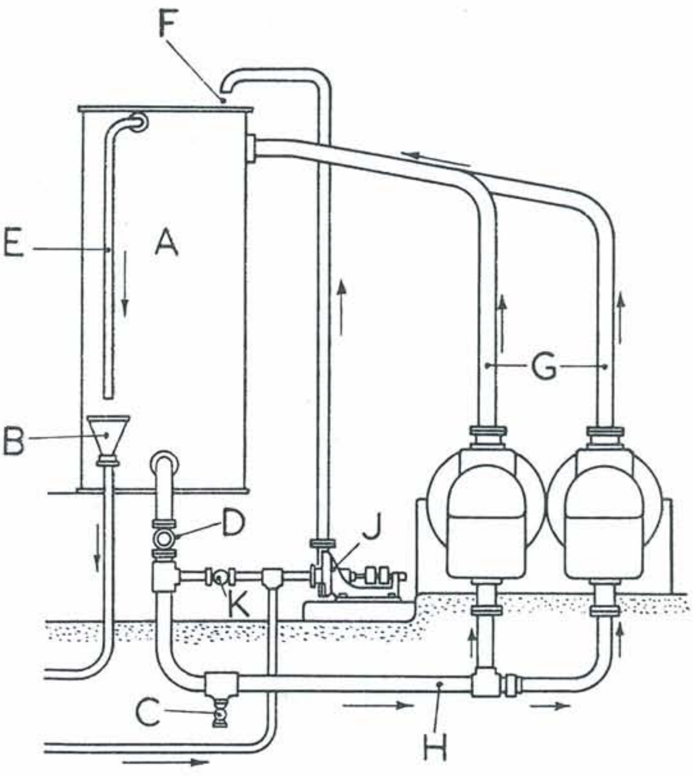


Fig. 24 *Double cylinder and monobloc engines*

- (*a*) *Vertical safety water tank*
- (*b*) *Tundish*
- (*c*) *Drain*
- (*d*) *Stop cock on inlet water pipe*
- (*e*) *Overflow pipe*
- (*f*) *Visible supply from pressure main or pump*
- (*g*) *Outlet water pipe from engine*
- (*h*) *Inlet water pipe to engine*
- (*j*) *Water pump*
- (*k*) *Valve in pump priming pipe*

Beware of running water through the jacket without the use of a water tank when the water is "hard," or muddy as the incoming water tends to **deposit its scale or mud in the water jackets,** which causes the castings to become overheated. Run-through water should be soft water, or water treated in some way so as to soften it.

Whether the water is run-through or pumped through the jackets it is necessary for the jackets to remain full at all times, except when it is purposely drained out. For example, when the water is pumped through it is always possible for a non-return valve or foot valve to stick open or leak. This might enable all the water to drain out when the engine is stopped without being observed and would be serious for two reasons:—

(i) Parts of the engine would be very hot and might fracture, or

(ii) The engine might be started without water until some parts were seriously overheated and even fractured.

This can be prevented by arranging the supply to be taken up from the pump or supply cock to say 2 feet (0·60 metres) above the cylinder, and for the water to pass out into a tundish and down a separate pipe to the inlet passages to the cylinder and breech end. No water could then pass out of the jackets when the engine stops.

Where a constant supply of water is available or where separate tanks cannot be used, the "run-through" system may be used in one of the following ways.

(iii) Where a continuously dependable supply of water **by gravity** is assured, the pipes may be arranged as shown in Figs. 19 and 20, the water running through the jackets to waste, a separate cock A, being fitted to the engine outlet pipe.

(iv) Where the supply of water is **not** dependable and is liable to cease suddenly, say, if air gets into the pump or the pump driving belt should break and no pump foot valve is fitted, the water would run out of the jackets with the engine stopped; then, on restarting, no water would be in the jackets for some time after starting, and the cylinder and breech end will become seriously overheated before the pump becomes operative.

To avoid this danger we advise the use of an overhead tank or a vertical tank A, see Figs. 21 to 24. The pump keeps this "safety tank" full instead of delivering the water direct to the engine. With this arrangement the pipes between the engine and the "safety tank" must be of the same bore as for the thermosyphon system.

Should the pump cease to deliver water, then the water in the system will continue to circulate, and will enable the engine to run with reasonable safety for a time, depending on the size of the "safety tank," during which time the water supply may be restarted or the attention of the attendant directed to the mishap before any damage is done. The "safety tank" should be as large as possible with the overflow pipe E led into a tundish B.

The supply of water may be adjusted by a cock D on the inlet water pipe but this cock must never be entirely closed when the engine is in operation.

(c) **Radiator Cooling System.** This system may be employed for use with soft rain or distilled water. When a radiator is installed in a confined space it is important that the air inlet to the radiator is away from any feature which may baffle the flow. Ample ventilation must be provided to permit the hot air being expelled from the room. When overheating is experienced it will probably be found that the fan belt is slipping. All rubber hose connections should be maintained in good condition.

QUANTITIES OF CIRCULATING WATER REQUIRED

RUN-THROUGH CIRCULATION

Water Capacity Run-Through Circulation		HD4 and IHD4		HD6 and IHD6		HH6 and IHH6		HD7, HH7 and IHH7		HD8, HH8 and IHH8		HD9, HH9 and IHH9		HD10, HH10 and IHH10		HD11, HH11, IHH11, 2HH11 and 2IHH11		HD12, HH12, IHH12, 2HH12 and 2IHH12		HD14, HH14, IHH14, 2HH14 and 2IHH14	
	Inlet Water Temperatures	Gals.	Ltrs.	Gals.	Ltrs.	Gals.	Ltrs.	Gals.	Ltrs.	Gals.	Ltrs.	Gals.	Ltrs.	Gals.	Ltrs.	Gals.	Ltrs.	Gals.	Ltrs.	Gals.	Ltrs.
Consumption per B.H.P. per hour at normal Load to maintain an outlet water temperature of 140°F (60°C).	50°(10°C.)	3.5	15.9	3.3	15.0	3.3	15.0	3.0	13.6	3.0	13.6	2.75	12.5	2.75	12.5	2.5	11.4	2.5	11.4	2.5	11.4
	70°(21°C.)	4.7	21.4	4.5	20.5	4.5	20.5	4.0	18.2	4.0	18.2	3.75	17.0	3.75	17.0	3.35	15.2	3.35	15.2	3.35	15.2
	90°(32°C.)	6.7	30.5	6.5	29.4	6.5	29.4	6.0	27.3	6.0	27.3	5.5	25.0	5.5	25.0	5.0	22.7	5.0	22.7	5.0	22.7
	110°(43°3.)	14.0	63.6	13.0	59.1	13.0	59.1	12.0	54.6	12.0	54.6	11.0	50.0	11.0	50.0	10.0	45.5	10.0	45.5	10.0	45.5

THERMO-SYPHON SYSTEM

Water Capacity Thermo-Syphon System		HD4 and IHD4	HD6 and IHD6	HH6 and IHH6	HD7, HH7 and IHH7	HD8, HH8 and IHH8	HD9, HH9 and IHH9	HD10, HH10 and IHH10	HD11, HH11, IHH11 2HH11 and 2IHH11	HD12, HH12, IHH12, 2HH12 and 2IHH12	HD14, HH14, IHH14, 2HH14 and 2IHH14
Capacity required per B.H.P. under temperate conditions	cubic feet	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	cubic metres	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12

EXHAUST SYSTEM

16. **EXHAUST PIPES.**—Figs. 26a to 26c.—The instructions concerning the general layout of the system are given in paragraphs 2 and 6.

It is important that the bore and length of the pipe both from engine to silencer and the primary outlet A to atmosphere approximate to the dimensions given in the table, paragraph 17, for a normal engine-house arrangement. The outlet pipe A should not be less than 11 feet (3.3 metres). An incorrect exhaust pipe system can adversely affect piston condition and engine performance, with increased exhaust temperature; our recommendations are those which are considered best for satisfactory operation.

The total length from the breech end to the end of the primary outlet pipe A should not exceed 23 ft. (7 metres) on the IHD4 to IHH7 engines and 27 ft. (7.7 metres) on IHH8 to IHH14 engines without using the secondary pipe B, excluding the silencer dimensions.

The silencer position should be such that the pipe length from the breech end should not be less than 7 feet (2.1 metres) and not greater than 15 feet (4.6 metres). The length of the primary pipe A in the table should never be exceeded by 2 feet (0.6 metres) without the use of a secondary outlet pipe B.

Where long pipes are a necessity it is customary to install a larger bore pipe to atmosphere over and above the primary outlet length recommended; this necessitates an outlet pipe having two diameters. This secondary pipe B should have a bore at least 1 inch (25.4 mm) larger than the outlet pipe A.

On installations where the pipe layout is long and tortuous, or there is a serious departure from our recommendations, then **we must be consulted as to the bores and lengths to avoid any detrimental effect on engine performance.**

It is not usually necessary to employ exhaust pipes of a total length greater than 35 to 40 feet (10.6 to 12.2 metres).

The end of the outlet pipe to atmosphere should be chamfered at an angle of about 60 degrees. Figs. 3, 4 and 26 show the layouts preferred with both the standard and additional straight-through tubular silencer.

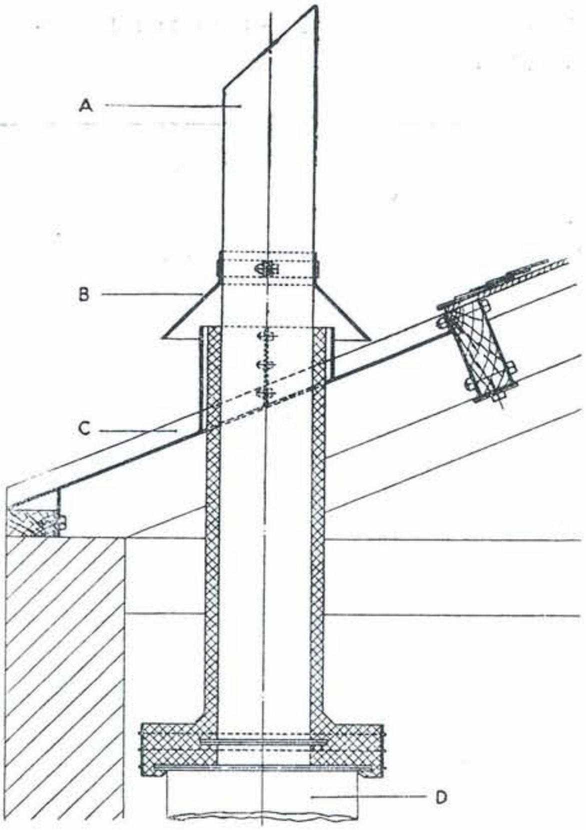


Fig. 25 *Arrangement of timbered roof protection*

(*a*) *Outlet pipe to atmosphere*
(*b*) *Weather cowl*
(*c*) *Roof cover plate*
(*d*) *Exhaust silencer*

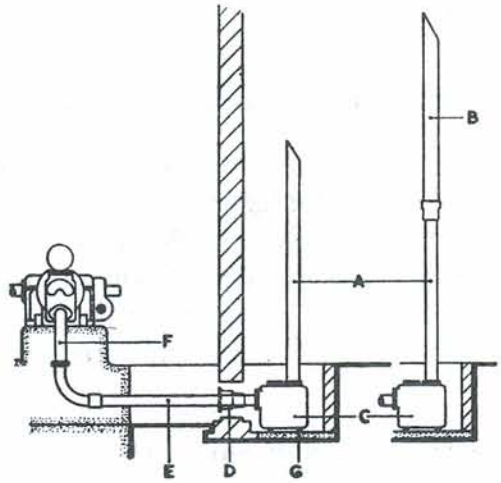


Fig. 26a

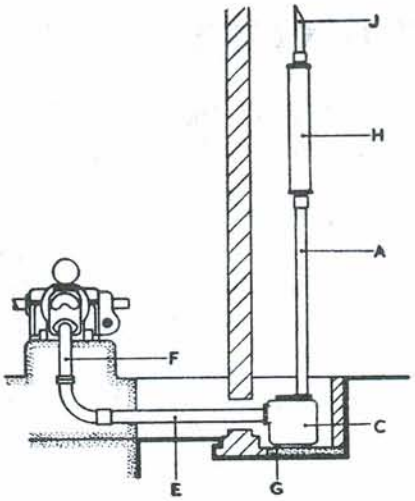


Fig. 26b

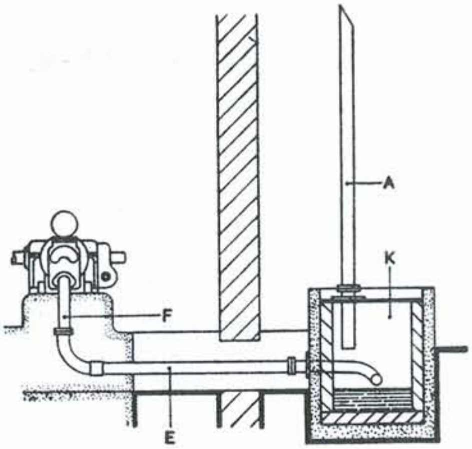


Fig. 26c

Typical exhaust systems

(*a*) *Primary outlet pipe*
(*b*) *Secondary outlet pipe*
(*c*) *Exhaust silencer*
(*d*) *Expansion socket*
(*e*) *Pipe from exhaust bend to silencer*
(*f*) *Engine exhaust bend*
(*g*) *Rollers for silencer*
(*h*) *Straight-through silencer*
(*j*) *Tail pipe*
(*k*) *Exhaust pit*

17. **EXHAUST PIPE BORES AND LENGTHS.**—Fig. 26a—The schedule gives dimensions which are considered the best for a normal layout and good engine operating conditions :—

Size of Engine		Exhaust Bend to Silencer				Silencer to Atmosphere				Standard Silencer Capacity	
		Bore		Length †		Bore		Length ‡			
		ins.	mm.	ft.	mm.	ins.	mm.	ft.	mm.	cu.ft.	cu. m.
Single Cylinder Engines	IHD4	2·5	64	7	2130	2·5	64	14	4260	0·7	0·02
	IHD6	3	76	7	2130	3	76	14	4260	1·4	0.039
	IHH6	3	76	7	2130	3	76	14	4260	1·4	0·039
	IHH7	3	76	7	2130	3	76	14	4260	1·4	0·039
	IHH8	3·5	89	9	2745	3·5	89	18	5486	2·4	0·067
	IHH9	4	102	9	2745	4	102	18	5486	2·4	0·067
	IHH10	4	102	9	2745	4	102	18	5486	2·4	0·067
	IHH11	5	127	9	2745	5	127	18	5486	5·0	0.14
	IHH12	6	153	9	2745	6	153	18	5486	5·0	0·14
	IHH14	6	153	9	2745	6	153	18	5486	5·0	0·14
Monobloc Engines	2IHH11	5	127	*9	2745	5	127	18	5486	5·0	0·14
	2IHH12	6	153	*9	2745	6	153	18	5486	5·0	0·14
	2IHH14	6	153	*9	2745	6	153	18	5486	5·0	0·14

Size of Engine		Exhaust Bend to Silencer				Silencer to Atmosphere			
		Bore		Length		Bore		Length	
		ins.	mm.	ft.	mm.	ins.	mm.	ft.	mm.
Single and Double Cylinder Engines	HD4	2	51	7	2130	2·5	64	9	2745
	HD6	2·5	64	7	2130	3	76	9	2745
	HH6	2·5	64	7	2130	3	76	9	2745
	HH7	2·5	64	7	2130	3	76	9	2745
	HH8	3	76	*7	2130	3·5	89	12	3660
	HH9	3·5	89	*7	2130	4	102	12	3660
	HH10	4	102	*7	2130	4	102	12	3660
	HH11	4	102	*7	2130	5	127	12	3660
	HH12	5	127	*7	2130	5	127	12	3660
	HH14	6	153	*7	2130	6	153	12	3660
Monobloc Engines	2HH11	4	102	*7	2130	5	127	12	3660
	2HH12	5	127	*7	2130	6	153	12	3660
	2HH14	6	153	*7	2130	6	153	12	3660

* On double cylinder and monobloc engines the two engine exhaust bends F. Fig 26, are connected to a common fabricated steel or cast iron junction piece. The dimension specified is the length from the exhaust bend nearest to the silencer.

† Length from exhaust bend to silencer includes any short vertical connecting pipe and the 90 degree sweep bend to the horizontal pipe E.

‡ Length to atmosphere recommended and also included in a standard set of pipes, but does not include any secondary outlet pipe of larger bore.

When the exhaust silencer is placed at a greater distance from the engine than that recommended in the table above and within the limits specified in paragraph 16, the primary outlet pipe length may require modification to obtain optimum conditions; the length should be approximately double that of the pipe from exhaust bend F to silencer C.

18. **EXHAUST SILENCERS.**—Where an extra degree of quietness is needed then a ‘straight through’ tubular silencer may be incorporated in the length of the outlet pipe A to atmosphere and should be fitted with a tail pipe of length equivalent to 10 times the bore of the outlet pipe as shown in Fig. 26b. The length of the tubular silencer and its tail pipe must be included in the recommended primary outlet pipe length.

Snubber type silencers, or those which create a restriction in the pipe system, should not be used.

Certain applications permit of an exhaust pit being employed as shown in Fig. 26c; with this arrangement the pipe into the silencer should enter tangentially. The volume of the pit should be approximately 6 times the capacity of the standard silencer. The primary outlet pipe A to atmosphere may need to be altered in both length and diameter to avoid adverse effect through back pressure which will adversely influence engine performance. Extra exhaust silencing arrangements of this design should be submitted to us for approval. When water is used in the silencer pit both drainage and water level facilities must be provided.

Water sometimes accumulates in the silencer and a drain plug is provided for draining purposes. When fuel contains a high percentage of sulphur then condensation of water in the exhaust pipe can cause corrosion; long exhaust pipes to atmosphere should be avoided when using such fuels.

METHOD OF WORKING

19. The engine works on the "Four-cycle" principle.

SUCTION STROKE.—On the first forward or suction stroke of the piston, air is drawn into the cylinder through the air valve.

COMPRESSION STROKE.—On the return stroke the air is compressed into the combustion chamber, and fuel is then injected in the form of a fine spray, before the end of the stroke.

POWER STROKE.—The mixture of fuel and hot compressed air is ignited and the pressure resulting from the combustion drives the piston forward on the power stroke.

EXHAUST STROKE.—The exhaust valve having opened, the burnt charge is expelled by the return of the piston, when the valve again closes.

The cycle of operations is repeated as long as the engine is at work.

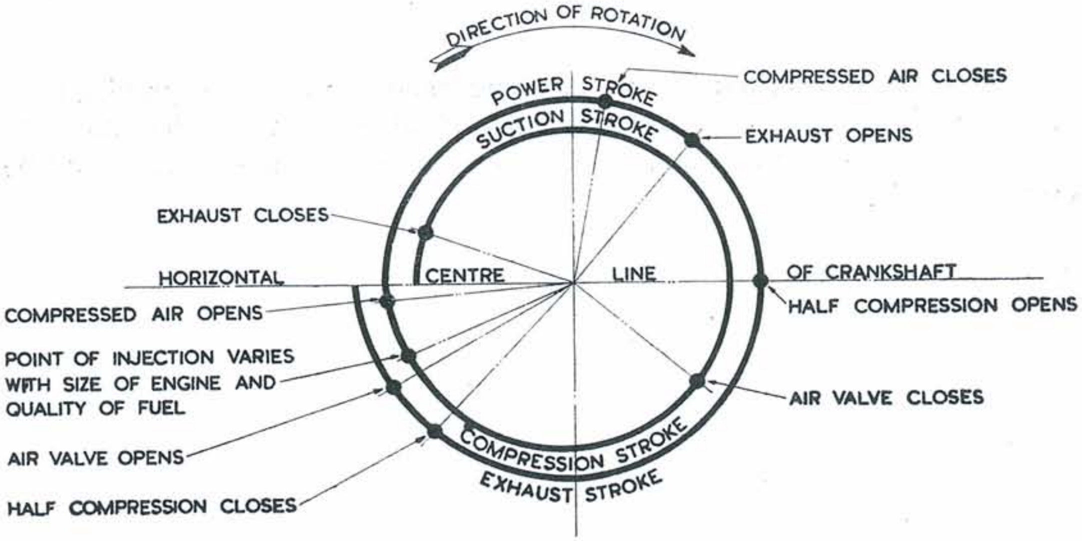


Fig. 27

VALVE SETTING DIAGRAM.

The diagram shows graphically one complete "cycle," or two revolutions of the crankshaft. The angles given are **approximately** those which the crankshaft occupies in relation to the horizontal centre line of the engine, when the valves are about to open or close. In the case of the fuel pump, the point when the plunger is commencing the delivery stroke, varies according to the size of the engine and to the fuel used.

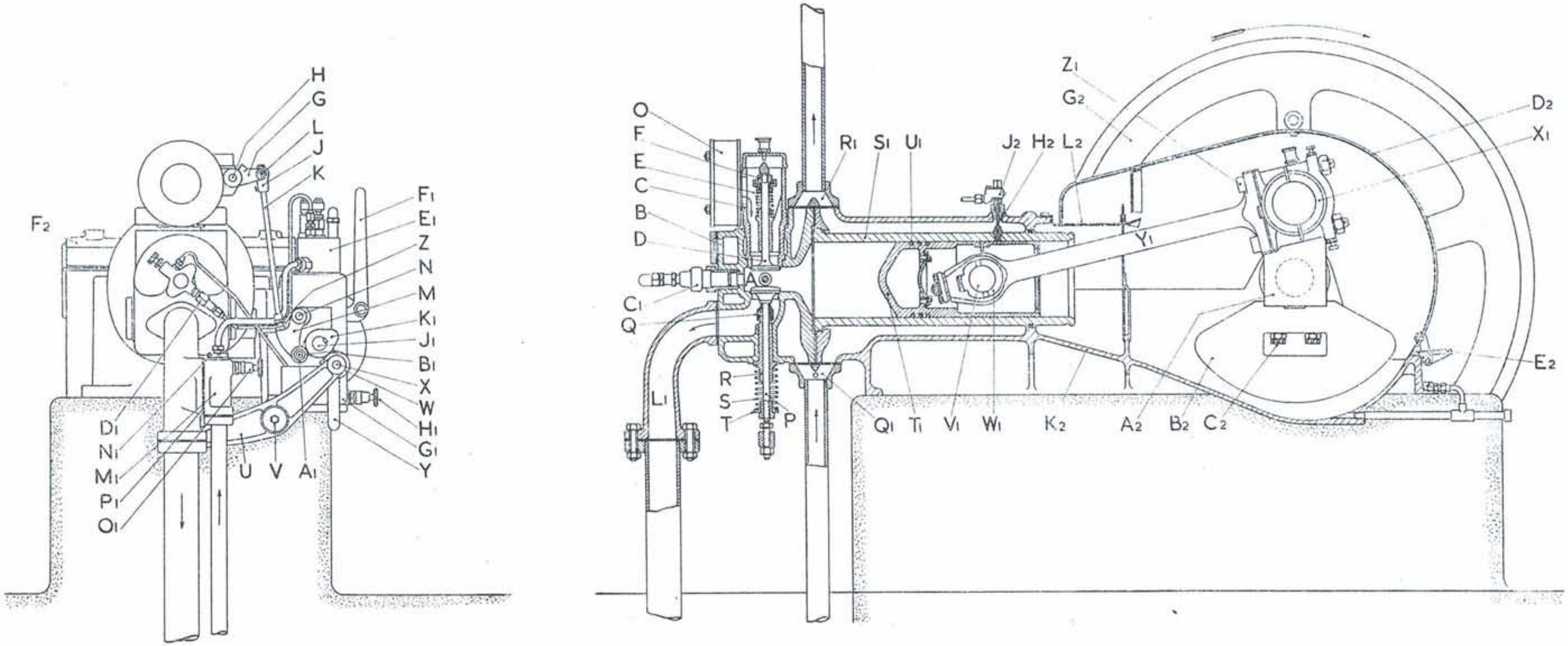


Fig. 28 *Sectional arrangement and end views of engine*

(*a*) *Combustion chamber*
(*b*) *Breech end*
(*c*) *Air valve block*
(*d*) *Air valve spindle*
(*e*) *Air valve spring*
(*f*) *Air valve pusher head*
(*g*) *Air valve lever*
(*h*) *Air valve lever fulcrum pin*
(*j*) *Eye for air valve rod*
(*k*) *Air valve rod*
(*l*) *Pin for air valve rod eye*
(*m*) *Air valve roller lever*
(*n*) *Fulcrum pin for roller lever*
(*o*) *Air silencer—complete*
(*p*) *Exhaust valve*
(*q*) *Exhaust valve sleeve*
(*r*) *Exhaust valve guide*
(*s*) *Exhaust valve spring*
(*t*) *Exhaust valve spring collar*
(*u*) *Exhaust valve lever*
(*v*) *Exhaust valve lever fulcrum pin*
(*w*) *Exhaust valve roller*
(*x*) *Exhaust valve roller pin*
(*y*) *Exhaust valve lifting handle*
(*z*) *Adjusting screw for air valve rod*
(*a1*) *Air valve roller*
(*b1*) *Air valve roller pin*
(*c1*) *Fuel sprayer and strainer*
(*d1*) *Strainer on sprayer*
(*e1*) *Fuel pump*
(*f1*) *Fuel pump handle*
(*g1*) *Overflow oil pot*
(*h1*) *Overflow oil pot drain valve*
(*j1*) *Sideshaft*
(*k1*) *Combined cam*
(*l1*) *Exhaust bend*
(*m1*) *Fuel heater*
(*n1*) *Fuel heater strainer body*
(*o1*) *Release valve on heater*
(*p1*) *Asbestos packing for heater*
(*q1*) *Water inlet branch*
(*r1*) *Water outlet branch*
(*s1*) *Cylinder liner*
(*t1*) *Piston*
(*u1*) *Piston rings*
(*v1*) *Piston pin*
(*w1*) *Small-end bearing*
(*x1*) *Large-end bearing*
(*y1*) *Connecting rod body*
(*z1*) *Connecting rod bolts*
(*a2*) *Crankshaft*
(*b2*) *Balance weights*
(*c2*) *Balance weight studs*
(*d2*) *Splasher guard*
(*e2*) *Guard support*
(*f2*) *Main bearing caps*
(*g2*) *Flywheel*
(*h2*) *Liner oil tube*
(*j2*) *Back pressure valve*
(*k2*) *Bedframe*
(*l2*) *Piston splasher guard*

INSTRUCTIONS FOR WORKING

20. **All instructions are based on a running time of 50 hours per week.** Where engines are installed to run for longer periods, then routine attention must be given correspondingly more frequently.

The owner should see that these instructions are properly carried out, together with the recommendations suggested in the "Diagnosis Chart" and "Inspection Chart," paragraphs 137 and 138.

Routine examinations and overhauls are the secrets of successful running.

All machinery is valuable, and it is therefore worthy of the best possible care and attention. This is especially the case in installations when life and production may be dependent on the regular and efficient working of the engine.

21. **INSURANCE.**—It is desirable to have periodical examinations of the principal parts by a skilled engineer, and we call attention to the advantages which are to be gained by having the machinery insured by one of the leading Industrial Insurance Companies, who provide periodical inspection services by surveyors, who have been specially trained for such work.

22. **GUARANTEE.**—Our guarantee is conditional on the fuel and lubricating oil being approved by us, and on the engine being operated according to the recommendations in this Instruction Book.

23. **Log Sheet.**—It is a good plan to keep a **Log Sheet** which enables any possible engine troubles to be anticipated, and give an indication when those parts which require periodical examination were last inspected. A specimen log sheet is given below :—

SIZE OF ENGINE "IHH10." ENGINE NO. 148232.

1958	Air and exhaust valves inspected	Air silencer or filter cleaned.	Piston withdrawn for examination and combustion chamber cleaned	New piston rings fitted	Connecting Rod		Main bearings adjusted crankshaft examined	Water jacket and water pipes cleaned	Fuel sprayer and strainer cleaned	Fuel heater, strainer, and all fuel pipes cleaned	Fuel pump cleaned, lift of valves examined	Air receiver and piping drained. Air compressor and valves cleaned
					Large-end bearing rod adjusted and crankpin examined	Small-end bush adjusted or replaced and piston pin examined						
JAN.		26th	26th	26th	26th	26th			12th			19th
FEB.	16th							9th		23rd		
MAR.		4th					9th					16th
APRIL		6th			13th							
MAY		18th								18th		18th
JUNE	1st										8th	

24. **ENGINE-ROOM.**—The engine-room should be adequately lighted and well ventilated with plenty of room round the engine. Do not allow unauthorised persons to enter.

The engineer-in-charge should take a pride in his work and see that both the engine and the engine-room are kept perfectly clean and tidy. The engine should be kept free from dust and grit; an engine which is well cared for throughout will give complete satisfaction. A dirty and neglected engine may be expected to have a shorter life, and the wearing parts will invariably require to be renewed more frequently.

The engineer should be fully acquainted with all the working parts and make any adjustments as soon as they appear necessary. See that there is always an ample supply of fuel and lubricating oil available, and that spare parts are in stock, well greased and ready for use.

25. **EFFICIENT CONDITION.**—The engine will be found to be remarkably reliable and consistent when in efficient condition. Unfortunately, this state of affairs is sometimes abused by allowing the engine to run until something goes wrong, instead of giving the necessary periodical cleaning and readjustment in order to maintain the engine in a permanently efficient condition. We strongly advise the operator methodically to clean and adjust the engine periodically, despite the fact that the engine is running perfectly.

Two essential conditions to be maintained in an efficient state are:—

(a) The Mechanical condition.

(b) The Combustion condition.

26. **MECHANICAL CONDITION.**—The engine is designed that wear and tear are reduced to a minimum, and although the operator will be little troubled in this direction under normal circumstances, it is, nevertheless, necessary to examine periodically the moving parts and to satisfy himself as to their satisfactory condition.

27. **COMBUSTION CONDITION.**—The maintenance of an efficient process of combustion is of maximum importance, and upon it depends the successful performance of the engine.

Efficient combustion depends on the maintenance of the fuel injection apparatus, the cleanliness of the fuel system, and a correct exhaust system.

No matter how perfectly engine items are designed, they nevertheless require to be cleaned periodically if consistent running is to be maintained. The cleaning process is a simple matter but sometimes it is neglected as long as the engine will run.

The Golden Rules to follow are:—

(a) Do not wait until the engine gives trouble before examining the fuel mechanism, but inspect periodically even if the engine is running perfectly.

(b) When the exhaust shows a tendency to become discoloured more than normal, find out the cause.

28. **EXHAUST TEMPERATURE AND LOAD.**—The use of a thermometer can be used to give an indication of the power developed in the cylinder and for checking that each cylinder is taking its equal proportion of the load. Exhaust temperature readings at normal load when the engine is first installed under site conditions can be noted and used as a guide for subsequent comparisons. Higher temperatures will occur if the engine is overloaded or in imperfect condition.

Site conditions affect the temperature readings so also will the type of thermometer or pyrometer employed.

29. **REPAIRS AND SPARE PARTS.**—Make adjustments and repairs as soon as found necessary. See that the spare parts are in stock; this is important where engines are a distance from the works. Repairs should be entrusted only to skilled mechanics.

When ordering spare parts state the quantity required and the correct name and part number as given in the "Diagram of Parts."

30. **CRITICAL SPEEDS.**—On double cylinder engines the torsional vibration characteristics of the dynamic system formed by the engine, shafting, and driven machine must always be investigated at the design stage to avoid torsional oscillation at the normal running speed. Alterations may be necessary to the driven shafting in order to position dangerous critical speeds away from the running speed.

The engine must not be run in the vicinity of a critical speed.

Certain speeds lower and higher than the normal running speeds may also be dangerous, and where they exist within the running range, then it is necessary to pass through them as quickly as possible.

Should it be necessary to run the engine temporarily at a slower speed then the attendant must be on the alert for any rough running.

Once a critical speed has been located then this zone should be avoided.

The drive should never be modified before submitting particulars so that danger from torsional vibration may be avoided.

31. **CORRESPONDENCE.**—Always quote the **engine type letters,** and **the number** as stamped on the engine nameplate.

Always accompany any complaint, or request for advice, by a set of log sheets.

PREPARING TO START

32. The engine must be thoroughly cleaned down after installation and all dust and dirt removed from the engine-room before any attempt is made to start the engine.

33. The procedure given below should be methodically followed; the instructions are given in brief since their chief purpose is to remind the engine attendant of the items requiring attention prior to starting the engine.

(a) **BELT OR CLUTCH.**—When starting an engine the belt must **always** be on the loose pulley, or if a clutch is used, it must be put out of gear.

(b) **COMPRESSED AIR RECEIVER, STOP VALVE AND PIPE.**—When first charging up the receiver raise the pressure to about 10 p.s.i. (0·7 kg. per cm.^{2}). Then disconnect the air pipe at the starter valve on the cylinder, open the stop valve quickly, and blow the air to waste. This will blow away any scale or dirt in the valves or pipe. On larger sizes the pipe from the compressor to the receiver should be disconnected in the same way at the receiver and air blown through the pipe by working the compressor.

(c) **STARTING WITH COMPRESSED AIR.**—See that the pressure gauge registers the correct starting air pressure.

For the first start after erection, or if the pressure is lower than that given in technical data, it will be necessary to prepare and start the belt driven air compressor or combined engine and air compressor set. When the belt driven compressor is driven by the engine the first charging of the receiver must be effected by working the compressor by hand. The loose handle must be screwed into the rim of the driving pulley and the receiver should then be charged up to not less than 50 p.s.i. (3·5 kg. per cm.^{2}).

(d) **HEATING LAMP.**—This should be prepared in accordance with the instructions supplied with the lamp. When properly lit, place the lamp with the burner directed so as to project a strong flame against the ignition tube until the tube appears cherry red in colour, which will indicate a sufficient temperature to ignite the charges. The lamp is required for hand starting, or when the air pressure is low.

On the earlier double cylinder engines the flame need only be applied to the ignition tube of the left-hand engine.

(e) **MECHANICAL LUBRICATOR.**—Fill the sight feed glasses with a saturated salt solution, and fill the lubricator reservoir with oil. Adjust the feeds to the required number of drops, see paragraph 125. Prime the oil pipes by working the driving rod by hand.

(f) **Main Bearings, Oil Wells for Gearwheels and Pump Cam, all independent Lubricators and Oil Holes in the Valve Gear, Fuel Pump Mechanism and Starter Valve Gear.**—Lubricate and see there is sufficient oil in all the parts above. Oiling rings for the crankshaft bearings should be examined to see they revolve freely. The crankshaft and sideshaft gearwheels may be lubricated with oil and graphite.

(g) **COOLING WATER.**—Make sure the cock in the inlet pipe from the tanks is open, also that the ball cock is in good working order and is connected to the cold water supply for maintaining the water level in the tanks.

(h) **FUEL TANK.**—Fill the tank, being careful to pour all the fuel through the strainers. Open the cock of the fuel supply tank, or if an auxiliary refined oil tank is provided, close the cock of the main tank and open that on the auxiliary tank.

(i) **PRIMING THE FUEL PUMP.**—Open the sprayer relief valve, prime the pump by working it by hand. A relief plug is fitted on the pump suction. **Petrol spirit must not be used.**

For viscous fuels, a refined oil tank is required, the pipe from which must be coupled up to the union at the top of the heater so that refined oil can be used until the more viscous fuel in the heater has become sufficiently hot and **fluid** to be used.

(j) **EXHAUST VALVE AND HALF COMPRESSION CAM.**—Place the roller under the half compression cam.

(k) **CONNECTING ROD LARGE-END BEARING.**—First turn the flywheel round until the crankshaft is at the lowest position when any oil in the centrifugal ring will at once run down to the crankpin. **Immediately before starting, prime the bearing with oil by filling the cup provided, also flush the pipe from the lubricator to the ring lubricator until the ring is full,** to ensure an ample supply of oil to the crankpin immediately the engine is started. It is also important that there should be no dirt in the ring lubricator, the oil passages through the crankshaft and the oil supply pipes.

(l) **CRANKSHAFT POSITION.**—Set the crankshaft at an angle of about 10 to 20 degrees above the horizontal and on the Power stroke, when all valves are closed. The sideshaft bracket and the side of the combined cam can be marked with the setting position to assist the engine attendant. **Close the exhaust valve,** being particularly careful to let the valve return to its seat slowly; careless handling may cause fracture of the valve.

On double cylinder engines the crankshaft of the **right-hand** engine must be set at an angle of 10 degrees above the inner dead centre on the **power** stroke. In this position **the left-hand** crankshaft will be 10 degrees above the inner dead centre on the **suction** stroke.

(m) **FLYWHEEL BARRING GEAR.**—Most engines have a barring bracket secured in the foundation and the flywheel is turned by using a barring bar. **Disengage** the hand turning gear pinion from the flywheel teeth and drop the catch into position when this type of gear is installed.

(n) **GOVERNOR LEVER STARTING POSITION.**—Raise the lever into its correct starting position by the prop.

STARTING

34. **HAND STARTING.—(a) For engines not fitted with compressed air starting equipment.**—Remove the wick holder from the breech end and insert a length of tinder wick about 1·5 inches (40 mm.) long into the end of the holder. Light the wick and screw the holder quickly into the breech end. Rotate the crankshaft as quickly as possible with the starting handle, and when a fair speed is attained move the exhaust valve lifter downwards, thus closing the exhaust valve. Continue to rotate the crankshaft until the ignitions commence. Remove the starting handle from the crankshaft and slide the exhaust valve roller to the left and insert the taper pin to hold it in position. When the engine is running up to speed, the main fuel tank cock can be opened and the starting oil tank cock can be closed.

(b) When compressed air is not available for engines fitted with compressed air starting equipment.

In the event of the compressed air supply failing or the air pressure is insufficient for the initial start, the engines up to HH14 and IHH14 types may be started by hand. Two or three men are necessary, one to operate the fuel pump and the others to turn the flywheel round as quickly as possible.

Method of procedure:—

(a) Place the heating lamp in position and carry out all the instructions for "Preparing to start."

(b) Place the exhaust roller W Fig. 28 under the half compression cam.

(c) Open the exhaust valve by the lifting handle Y Fig. 28.

(d) Close the sprayer relief valve and inject two or three fuel charges by the pump handle J1 Fig. 35.

(e) Turn the flywheel round as quickly as possible, and when sufficient speed has been obtained and the engine piston is about to make its next compression stroke, first close the exhaust valve and inject more fuel by quick movement of the fuel pump handle J1 Fig. 35. The charge will then be fired when the inner dead centre is reached.

(f) As soon as the engine speed is sufficient, the exhaust valve roller W Fig. 28 must be moved to the full compression cam and all other matters attended to in the normal manner.

(g) The governor prop should automatically disengage when the engine runs up to speed. Do not fix the prop in any way which will prevent it from falling down.

Never turn the flywheel by placing the foot on the arms—this procedure is dangerous.

35. **STARTING WITH COMPRESSED AIR.**—When the "Preparing to Start" instructions have been attended to and the attendant is thoroughly satisfied the engine is in order, proceed as follows:—

HD4 to HH7 and IHD4 to IHH7 ENGINES.—When air starting system is employed.

(a) Place the crankshaft on the outer dead centre so that the fuel pump roller is off the rise of the cam. The sprayer relief valve coupled to the sprayer must be closed and the fuel pump operated by hand until the oil feels "solid." With a quick movement inject one or two charges of fuel into the combustion chamber.

(b) Turn the crankshaft to about 20 degrees above inner dead centre on the power stroke, i.e., when both exhaust and air valves are closed.

(c) Slide the starter lever handle J, Fig. 61, towards the cam, bringing the starter lever over the starter cam.

(d) Open the air receiver stop valve by turning the handle to allow the air to pass to the starter valve.

(e) After 2 or 3 revolutions and as the engine speed increases, move the exhaust valve roller away from the half compression cam so that full compression is obtained in the cylinder.

(f) When the fuel charges are not ignited immediately, inject an oil charge by quick operation of the fuel pump handle J1, Fig. 35. Ignition will not take place with the half compression cam in operation when starting from cold, but it is necessary to use it for a few revolutions to enable the engine speed to increase sufficiently to turn against full compression.

(g) Slide the starter handle away from the cam; do this as soon as possible after ignitions have begun.

(h) Close the air receiver stop valve.

HH8 TO HH10 and IHH8 to IHH10 ENGINES

(a) Place the crankshaft on the outer dead centre so that the fuel pump roller is off the rise of the cam. The sprayer relief valve coupled to the sprayer, must be closed and the fuel pump operated by hand until the oil feels "solid." With a quick movement inject one or two charges of fuel into the combustion chamber.

(b) Place the crankshaft from 10 to 20 degrees above the inner dead centre on the power stroke.

(c) Open the air receiver stop valve to allow the air to pass to the starting valve D, Fig. 62, or the cam controller valve A, Fig. 65.

(d) On engines fitted with the combined charging and starting valve, place the starting handle K, Fig. 62, in the notch marked "START."

(e) After two or three revolutions and as the engine speed increases move the exhaust roller away from the half-compression cam so that full compression is obtained in the cylinder and the fuel charges are ignited. When the fuel charges are **not** ignited immediately inject an oil charge by operating the fuel pump handle quickly. As soon as ignition occurs reduce the fuel charge by slightly re-opening the sprayer relief valve until the engine speed is up to normal, when the relief valve must be closed. Ignition will not take place with the half-compression cam in operation when starting from cold, but it is necessary to use it for a few revolutions to enable the engine speed to increase sufficiently to turn against full compression.

(f) Place the starting valve handle K, Fig. 62, into the notch marked "WORK," Do this as soon as ignition commences.

(g) Close the air receiver stop valve.

(h) The governor prop will automatically disengage when the engine runs up to speed. Do not fix the prop in any way which will prevent it from falling down.

HH11 to HH14 and IHH11 to IHH14 Engines.

(a) Place the crankshaft in the outer dead centre position so that the fuel pump roller is off the rise of the cam. Open the sprayer relief valve coupled to the sprayer, and give the fuel pump several strokes by hand, to remove any possible air locks in the fuel system. Close the sprayer relief valve and hand operate the fuel pump until the oil feels "solid".

(b) Place the crankshaft from 10 to 20 degrees above the inner dead centre position on the power stroke.

(c) Slide the exhaust valve roller to the half-compression position.

(d) Open the air receiver stop valve to allow air to pass to the cam controller valve, Fig. 64, and then to the starter valve, Fig. 65.

(e) After two or three revolutions, and as the engine speed increases, move the exhaust cam roller away from the half-compression cam, so that full compression is obtained and the fuel charges are ignited.

(f) As soon as ignition occurs, reduce the fuel charge by slightly opening the sprayer relief valve until the engine speed is up to normal when the relief valve must be re-closed.

(g) Close the air receiver stop valve.

(h) The governor prop should automatically disengage when the engine has run up to speed. Do not fix the prop to prevent it from falling down.

Double Cylinder Monobloc Engines.

(a) Place the crankshaft in the outer dead centre position so that the fuel pump rollers are off the rise of the cams. Open the sprayer relief valves coupled to the sprayer, and give the fuel pumps several strokes by hand to remove any possible air locks in the fuel system. Close the sprayer relief valves and hand operate the fuel pumps until the oil feels "solid".

(b) Place the crankshaft such that it is from 10 to 20 degrees above the inner dead centre position on the power stroke of either cylinder.

(c) Slide both the exhaust valve rollers to the half-compression position.

(d) Open the air receiver stop valve to allow air to pass to the cam controller valve, Fig. 64, which, in turn, admits the air to the appropriate starter valve, Fig. 65.

(e) After two or three revolutions and as the engine speed increases, move the exhaust cam roller on No. 1 cylinder away from its half-compression cam. As soon as ignition occurs on this cylinder, move No. 2 exhaust cam roller away from its half-compression cam.

(f) As soon as ignition occurs on No. 2 cylinder, reduce the fuel charges to both cylinders by slightly opening the sprayer relief valves, until the engine speed is up to normal when both relief valves must be re-closed.

(g) Close the air receiver stop valve.

(h) The governor prop will automatically disengage when the engine has run up to speed. Do not fix the prop in any way which will prevent it from falling down.

DOUBLE CYLINDER ENGINES.—Separate bedframe type.

Make sure that the fuel pumps and pipes are thoroughly primed. Open the sprayer relief valve and starter valve on each cylinder. When all is ready open the air receiver stop valve. As soon as the engine has made one complete revolution shut off the air to the right-hand cylinder, almost close the sprayer relief valve but not fully, and move the roller over on to full compression. Shut off the air to the left-hand cylinder and as the engine gains speed close the relief valve, moving the exhaust roller over to full compression. Close the air receiver stop valve.

The load must not be put on until both sprayer relief valves are closed and full compression put on both cylinders.

36. **STARTING WITH REDUCED AIR PRESSURE.**—The air pressure in the receiver should not be less than 150 p.s.i. (10.00 kg. per. cm.^{2}), for satisfactory starting, but if for any reason the air pressure is lower the **engine may be started with the assistance of the heating lamp or tinder wick** at the higher pressure no pre-heating is necessary. In this case proceed as instructed above, but do not move the exhaust roller away from the half-compression cam until ignition has begun. The fuel charges are fired whilst the half-compression cam is in operation, when the lamp is employed.

CAUTION.—Charges of fuel must not be injected by the pump handle when the engine has begun to ignite the fuel charges regularly.

37. **RE-CHARGING AIR RECEIVER.**—When running steadily at normal speed and before putting any load on the engine, the receiver should be re-charged as quickly as possible in the following manner:—

HD4 to HH7 and IHD4 to IHH7 Engines when starter valve is fitted.

(a) Open the air receiver stop valve if it has been closed after starting.

(b) The starter lever handle must be at left, i.e., with the starter lever away from the starter cam.

(c) Open wide the sprayer relief valve S Fig. 49, if this design of sprayer is fitted or, lift the fuel pump handle, and hold it up thus preventing any fuel being injected into the combustion chamber. **Immediately this is done and not before,** open the starter valve by charging handle M Fig. 61.

(d) When the engine speed has considerably decreased, release the charging handle to close starter valve, afterwards release the fuel pump handle to allow the pump to operate.

(e) The engine will soon regain speed and the re-charging must be repeated until the correct starting pressure is obtained.

(f) Do not repeat the re-charging operations too quickly, this tends to overheating of the valves and springs.

(g) Close the air receiver stop valve.

IMPORTANT.—On no account must the starter valve C be open whilst the fuel is being injected into the combustion chamber. The fuel pump handle F1, Fig. 28, must always be lifted before the starter valve C is opened and the starter valve must be closed before the fuel pump is released.

HH8 to HH10 and IHH8 to IHH10 engines.

(a) Open the air receiver stop valve.

(b) Open wide the sprayer relief valve thus preventing fuel being injected into the combustion chamber.

(c) **Immediately this is done and not before,** place the handle K into the notch marked "CHARGE," No. 3, Fig. 62. In this position the starter valve D is held open and the valve F is free to lift, when the air in the engine cylinder is forced into the receiver.

(d) When the engine speed has considerably decreased, first put the tumbler under the governor lever. Then put the starting handle K, Fig. 62, back into the notch marked "WORK," and close the relief valve N.

The engine will soon regain speed, and these operations must be repeated, alternately working the engine and charging the air receiver until the correct pressure is obtained. Do not repeat these operations too quickly as these would tend to overheating of the valves and springs.

(e) Close the air receiver stop valve.

IMPORTANT.—On no account must the starter valve D, Fig. 62, be open whilst the fuel is being injected into the combustion chamber. The sprayer relief valve must always be opened before the charging valve is opened, and the charging valve must always be closed before the sprayer relief valve is closed.

STOPPING

38. **METHOD OF STOPPING.**—To stop the engine open the sprayer relief valve. Alternative methods of stopping in case of emergency are to hold down the fuel pump by the handle, or lift the exhaust valve.

39. **COOLING WATER SYSTEM.**—When stopping, on engines not employing the thermo-syphon system of cooling, the engine should be allowed to cool down slowly to avoid any sudden inrush of cold water which may result in fracture of the breech end. When the water is suddenly shut off, the heat stored in the metal will quickly raise the water to boiling point resulting in damage of the breech end. It is, therefore, preferable to run the engine at no load for 5 or 10 minutes before stopping. The amount of cooling water circulating through the engine can be regulated by hand to prevent too rapid cooling.

Frost.—The engine-room temperature should not fall below 40° F. (4°C.).

When the engine is likely to be exposed to frost, it is advisable to drain the water from the cylinder jackets, etc., leaving all cocks open until restarting. A drain cock should be fitted in the water inlet pipe at the lowest point, in addition to the drain plugs or cocks on the engine. **Do not restart the engine without water in the jackets.**

When a ball valve is used in the cooling system, this must be first propped up, and any stop cock on the water inlet pipe closed before emptying the cooling system.

Similar precautions must be taken to drain all water from water cooled parts of compressed air equipment.

AIR and EXHAUST SYSTEM

40. The air is drawn from the atmosphere through a silencer or filter into the air valve block. This air is used to sweep the remaining products of combustion out of the combustion chamber, and to fill the combustion chamber with filtered air, before each compression stroke of the engine commences.

41. **EXHAUST CONDITION AND TEMPERATURES.**—The temperature is recorded by inserting a thermometer in the exhaust bend near to the breech end; a thermometer pocket is provided on most engines. The temperature varies with the amount of fuel consumed and the greater the quantity of fuel burned, the higher the temperature. Efficient combustion when running on normal load under standard atmospheric conditions will result in the recording of a certain temperature which can be recorded for reference against the thermometer reading obtained on site.

Should the temperature show some material variation, then the cause should be investigated, it may be due to:—

(a) Overloading of the engine.

(b) Unsatisfactory combustion condition due to an incorrectly set or faulty sprayer or fuel pump.

(c) Faults on fuel pump system. Pecker screws on monobloc engines may be out of adjustment or slack.

(d) Dirty or drying pistons.

(e) Incorrect exhaust pipe layout.

The load on the engine **must** always be regulated so the normal exhaust temperature is not exceeded; if the temperature tends to exceed the recorded normal figure under site conditions the load should be reduced.

An engine which is overloaded will give trouble.

When an engine is on arduous duty, or on prolonged continuous day and night running, it is preferable that the load be reduced and the exhaust temperature kept about 15°F. (11°C.) lower.

Correcting Dirty Exhaust:—

(a) The sprayers must be carefully examined to see that the nozzle holes are clear, and the valve seating perfect.

(b) The sprayer nozzle holes may have become enlarged through erosion, or by cleaning them out. New nozzles must then be fitted.

(c) Sprayer strainer passages choked, worn at the ends, or washers damaged, thereby restricting fuel supply. Replace or clean parts.

(d) The fuel pump must feel "solid" under hand-priming test.

(e) Fuel pump delivery valve stops worn.—Check lift and adjust or replace worn parts.

(f) The fuel pipes from the pump to sprayer should be clear.

(g) The air silencer must be clear of any fluff, grit or other foreign matter.

(h) The exhaust pipe system should be examined for restrictions.

(i) Cylinder liners may be worn.

(j) **The engine must not be overloaded.**

(k) Stuck piston rings arising from worn liners.

(l) Dry patches on pistons or stuck rings, if running on a very light gas oil change to another quality.

The efficiency of all these items is of extreme importance and the keynote of successful running. Our strong recommendation is for systematic cleaning, see inspection chart paragraph 137, and this will under normal conditions, maintain the engine in permanently efficient condition. Experience will enable the operator to determine the cause of a dirty exhaust on monobloc type engines; the exhaust thermometer will assist in determining which cylinder is at fault.

When balancing double cylinder engines for load it is important to make sure all exhaust pipes are free of obstruction, and the thermometer pockets are in a clean condition.

It is advisable to periodically change over the exhaust thermometers when the temperature of the cylinders are known. By observing their readings it can be determined if either of the thermometers are faulty.

Exhaust silencers and pipes should be examined when the engine receives a a general overall and, if necessary, repainted. Metal based paints, such as "Galvafroid" can be used although certain rubber based paints possess excellent heat and weather resisting qualities.

To clean the "straight-through" tubular silencers of the absorption type remove the detachable ends and clean the bore with a wire brush and renew the sound absorbent material if after prolonged use a general increase in the exhaust noise level is indicated.

FUEL SYSTEM

42. **FUEL.**—Each engine is tested on Class "A" fuel to the B.S.I. specification No. 2869.

Suitable fuels are approximately as follows, provided they comply with the particulars given below. We will advise on the suitability of a fuel on receipt of a sample or analysis.

Petroleum oils and Shale Oils	Specific Gravity	Beaumé Degrees
Refined Petroleum or Shale Oil, such as Kerosene or Paraffin	0.800 to 0.830	45 to 39
Gas Oil or Solar Oil	0.830 to 0.860	39 to 33
Light Crude and Diesel Fuel	0.860 to 0.890	33 to 27
Non-Asphaltic Fuels	0.890 to 0.940	27 to 18
Heavy Residual and Asphaltic Furnace fuels	0.890 to 0.970	27 to 13

Specific Gravity.—This is not a reliable guide to the quality of fuel suitable for an internal combustion engine. Fuel with a specific gravity over 0·900 should be tested for Coke, Ash and Asphaltum, also for viscosity.

Viscosity.—It is important that the fuel is sufficiently fluid to enable it to be atomised effectively. A viscosity of not exceeding 75 second at 100°F. (38°C.) in the Redwood No. 1 Viscometer is preferred. Unless the fuel is sufficiently fluid it will not run freely from the fuel tank to the heater and fuel pump.

Hard Asphaltum.—The hard asphalt in a fuel should not exceed 1 per cent., especially if the engine should usually work at or below one-third of its normal rated load.

Cold Test.—To ensure the fuel being sufficiently free from wax, the fuel should remain liquid at a temperature of 32°F. (0°C.).

Ash and foreign matter.—The fuel must be free from mineral acid, grit, and other foreign impurities. A slight ash content is a serious matter.

In viscous fuels the foreign matter is sometimes exceedingly small and hard, and will pass through almost any sieve. If this foreign matter is not removed it will inevitably cause serious wear of the piston, cylinder and fuel mechanism. We shall be pleased to advise as to what special means may be required for the purpose of removing this foreign matter on receipt of particulars of the fuel.

Water.—Water is difficult to separate out of viscous fuels.

Quality.—A low grade fuel may appear to be cheap, but in fact may be very expensive, owing to high asphalt, water, fibrous and other foreign impurities, and to the more cleaning and repairs necessary.

Use a fuel which has a specific gravity varying from 0·860 **to** 0·890 (33° **to** 27° **Beaume),** we do not recommend a fuel heavier than 0·890 sp. gr. unless it is of the non-viscous type.

FUEL SPECIFICATION.—Fuel bought should comply with the Class "A" Specification but when Class "B" fuels are used it is preferable to specify that the characteristics are well within the limiting figures of the specification. Our recommendation is to use a Class "B" fuel at the better end of the specification range.

Some fuels, with low specific gravity and viscosities, may tend to produce dryness of the pistons and fuel pump mechanism due to lack of the natural lubricating properties in the fuel.

British Standards Specification No. 2869 : 1957	CLASS "A"		CLASS "B"	
	Min.	Max.	Min.	Max.
Cetane Number	45	—	—	—
Viscosity centistokes at 100°F. (10°C.)	1.6	7.5	—	14
Viscosity Redwood No. 1 Seconds	30	45	—	65
Conradson Carbon residue, % by weight	—	0.1	—	1.5
Distillation, % by volume recovered at 357°C.	90	—	—	—
Closed Flash Point °F.	130	—	150	—
Water, % by volume	—	0.1	—	0.25
Ash, % by weight	—	0.01		0.02
Sediment, % by weight	—	0.01		0.05
Sulphur, % by weight	—	1.3		1.8
Strong acid number	nil		nil	
Sulphur, corrosive	Not more than slight tarnish		—	—

43. FUEL SERVICE TANK.—Fig. 29.

The tank should be positioned with its base not less than 2 feet (0.60 metres) above the fuel pump.

The fuel tank should be kept clean and should always be refilled before starting. All fuel must be poured through the strainers. Water which settles to the bottom of the tank must be drawn off **daily** through the drain cock E.

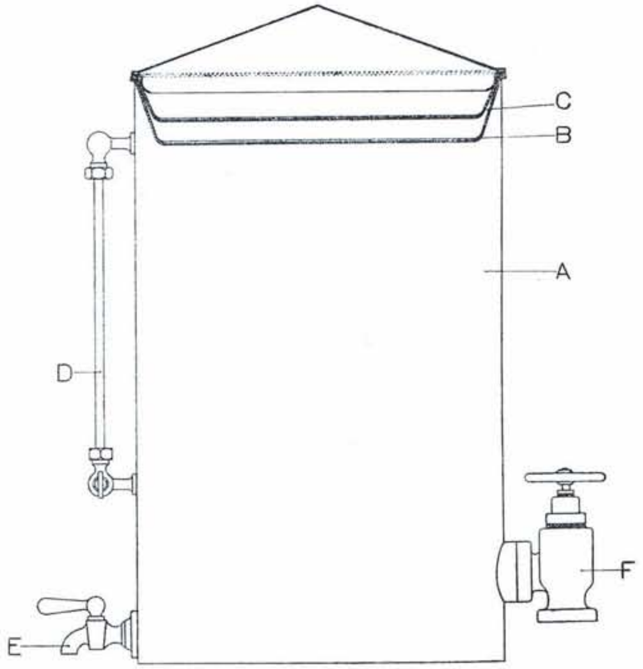


Fig. 29
Fuel tank as used on medium sized engines

- (*a*) *Fuel tank*
- (*b*) *Lower strainer*
- (*c*) *Upper strainer*
- (*d*) *Level gauge—when fitted*
- (*e*) *Drain cock*
- (*f*) *Screwdown valve*

The strainers B and C in the fuel tank must always be correctly in place and kept in good condition, so that foreign matter is not allowed to pass through. This strainer must be cleaned every **50 hours,** or as found necessary.

Under certain conditions it may be advisable to provide storage tanks of adequate capacity in addition to the engine service tank so that any water, sand or foreign matter may settle out. Any additional tank must be provided with a water drain cock and cleaning door. Pipes should not be taken from the bottom of the fuel tank.

On rectangular tanks a float and external fuel level indicator is fitted in lieu of a level gauge.

44. **FUEL PIPES.**—All pipes must be perfectly clean internally and all joints carefully made to avoid leakage. Refer to paragraph 60 concerning "Eliminating of air from fuel pump."

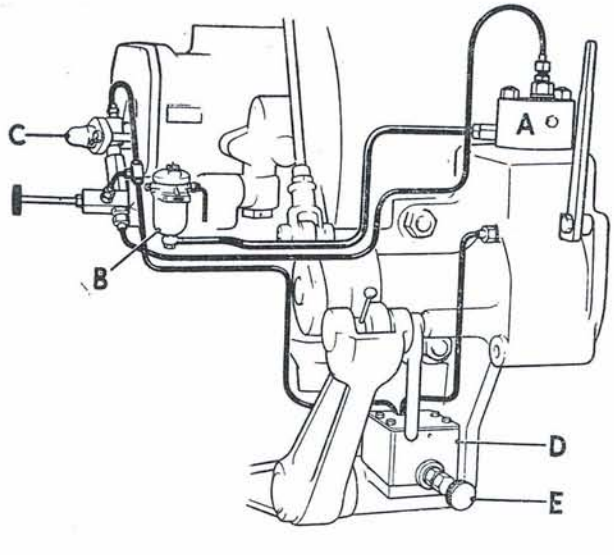


Fig. 30 *Arrangement of fuel pipes with a port controlled pump*

- (*a*) *Fuel pump*
- (*b*) *Fuel filter*
- (*c*) *Fuel sprayer*
- (*d*) *Overflow pot*
- (*e*) *Drain valve*

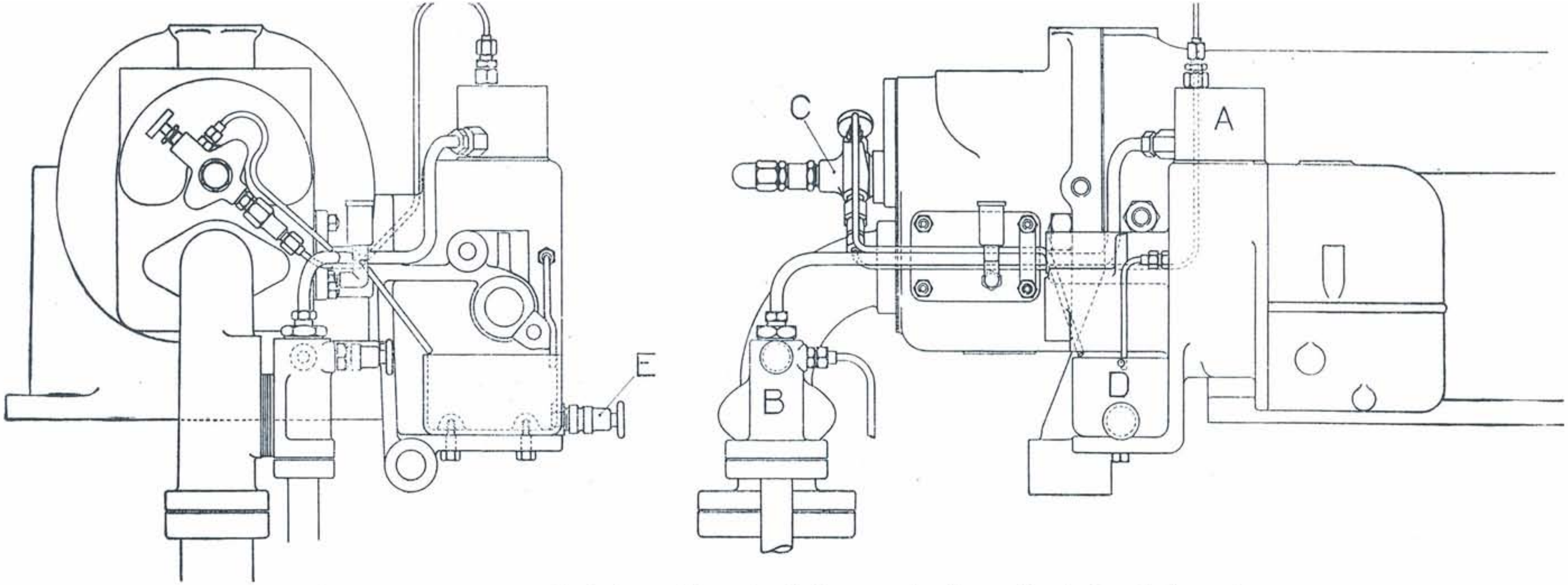


Fig. 31 *Arrangement of fuel pipes with a valve design pump for the smaller single cylinder engines*

On the larger engines the overflow from the fuel sprayer is fed into a tundish, see Fig. 32

(*a*) *Fuel pump* (*b*) *Fuel heater* (*c*) *Fuel sprayer* (*d*) *Overflow pot* (*e*) *Drain valve*

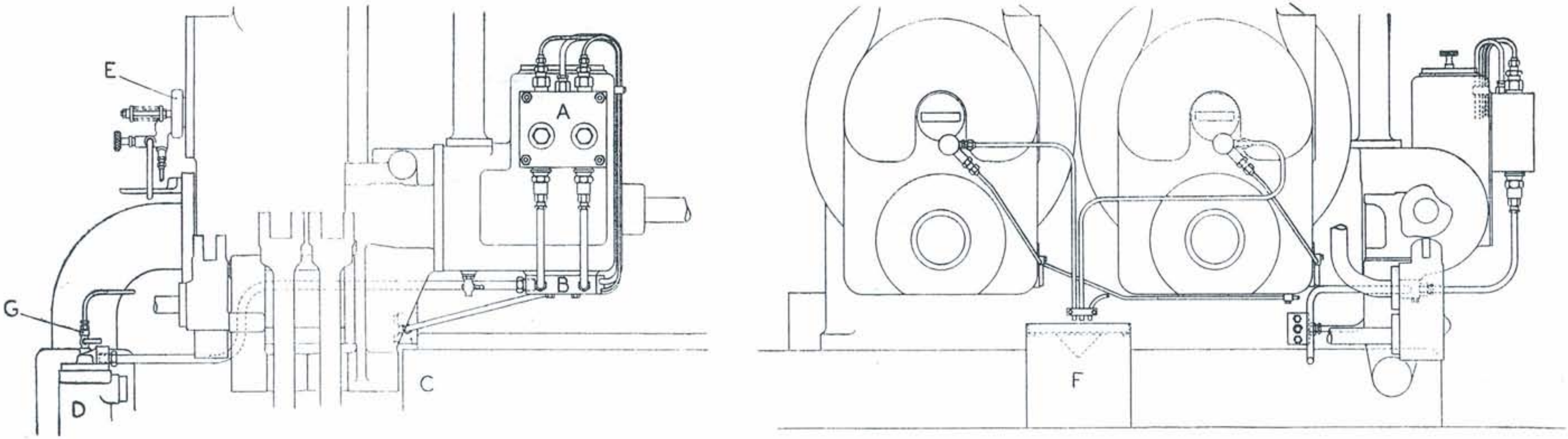


Fig. 32 *Arrangement of fuel pipes with a valve design pump for monobloc engines*

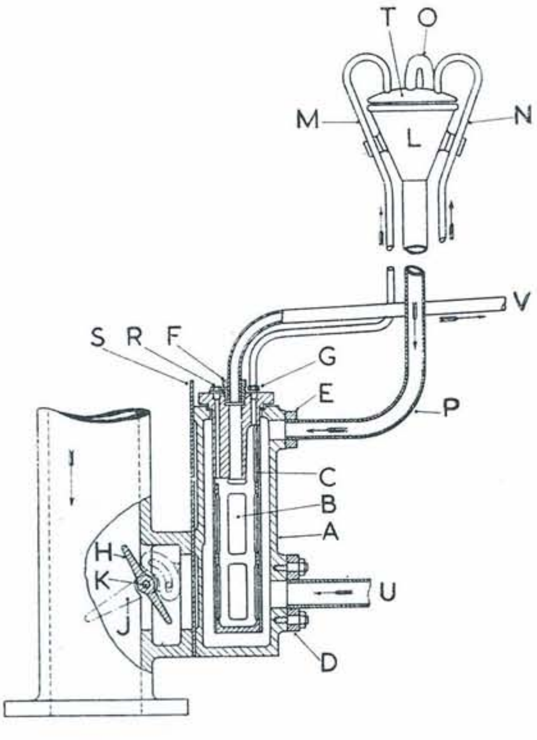
(*a*) *Fuel pump*
(*b*) *Junction box*
(*c*) *By-pass connection*
(*d*) *Fuel heater*
(*e*) *Fuel sprayer*
(*f*) *Drain tank*
(*g*) *Vent pipe cock*

FUEL FILTER AND HEATER

45. **FUEL HEATER.**—Fig. 33.—The fuel must be maintained sufficiently fluid to enable the fuel to be finely atomised, but not overheated. Should overheating occur with the unjacketed heater one or more thicknesses of asbestos should be placed between the heater and exhaust pipe. The heater valve may be partially or wholly closed when the engine has been running for about 15 to 30 minutes, as found best by experience.

The best temperature for Class "A" fuel is about 80°F. (27°C.), and for the more viscous fuel from 95 to 100° F. (35 to 38°C.).

Some fuels are quite fluid when cold, others require heating to 200°F. (93°C.) before they are sufficiently fluid for atomisation. The fuel will not atomise finely unless it is thin and fluid. These temperatures may be observed by placing a thermometer in holes on certain engines provided in the pump body. Do not overheat thin oils.



(a) Fuel heater body
(b) Strainer plug
(c) Strainer gauge
(d) Inlet pipe flange
(e) Flange for pipe from overflow
(f) Plug from outlet pipe to pump
(g) Plug for air vent pipe
(h) Regulator valve
(j) Handle for throttle valve
(k) Spindle for throttle valve
(l) Overflow tundish
(m) Air vent pipe
(n) Return pipe from sprayer
(o) Return pipe from control valve
(p) Return pipe from tundish
(r) Plug for refined oil connection—when fitted
(s) Plate
(t) Cover
(u) Pipe from fuel tank
(v) Pipe to fuel pump

Fig. 33 *Fuel heater and strainer*

When heavy viscous fuels are used, we supply a special arrangement to enable the fuel to be heated to a high temperature and for which special instructions are given in paragraph 132. With viscous fuels the suction pipe from the tank to the heater should be laid in the exhaust pipe trench. Should an oil become overheated when the regulator valve H is closed, one or more thicknesses of asbestos sheet, a steel plate or combination or both should be placed between the heater and the exhaust pipe.

Important.—Sometimes frothing indicates water in the fuel, and the remedy is to drain off any water at the heater and fuel tank; this should be done periodically.

The fuel heater strainer must be cleaned every **200 to 250 hours.** After long periods the tank, pipes and heater should be dismantled, and thoroughly washed out with paraffin to remove all slush, fluff, grit and water. Care must be taken when re-assembling to ensure perfect airtight joints. A choked vent pipe or air-lock in fuel system may cause carbonisation.

The heater body A attached to the exhaust pipe and on larger engines a valve H is used to deflect the exhaust gases towards the heater to increase its temperature. The valve H is adjusted by an external handle J. With fuels requiring very little heat a small unjacketed heater may be supplied.

46. **FUEL STRAINER.**—On engines with a fuel heater, Fig. 33 the strainer plug B is fitted inside the body and all fuel must pass through gauze C. A plug R is also provided to fit refined oil connections when using viscous fuel.

When an independent strainer is employed in the supply line between the service tank and fuel pump, in lieu of the strainer in the fuel heater, then this is usually attached to the breech end and consists of a casting containing a strainer plug covered with metallic gauze and a fabric covering.

The filter can be examined by removing the fuel pipe and the strainer plug. The metallic gauze complete with fabric can then be cleaned or replaced. Examine every **250 hours.**

The special fabric material should be used as it is resistant to mineral oil; ordinary fine woven cloth will rapidly depreciate. When fitting new fabric material make sure the fabric covers all the gauze, leaving no portion uncovered through which fuel could enter the system without passing through the fabric which should be wrapped twice round the gauze and then secured by copper wire at each end.

All strainers should be kept clean and in good condition.

47. **FUEL FILTER.**—Fig. 34. On engines fitted with a port controlled fuel pump a filter of the felt pad design is used in lieu of the metallic gauze and fabric filter covered in paragraph 46.

This filter must be cleaned regularly and it is customary to replace the felt pad with new ones each **2,500** hours according to condition.

First remove the cover by unscrewing the nut on the top when the filtering element will be exposed. The filter pads can be cleaned by compressed air, in which case, both ends of the pack should be closed by corks, one of which should carry a bicycle valve to admit compressed air from a hand pump or other supply. As the air passes from the inside to the outside of the pads any dirt is carried away and can be rinsed off.

The perforated support for the pads can be cleaned by immersion in clean fuel but care needs to be exercised to see that any dirt removed does not settle on the inside which would subsequently pass into the fuel system.

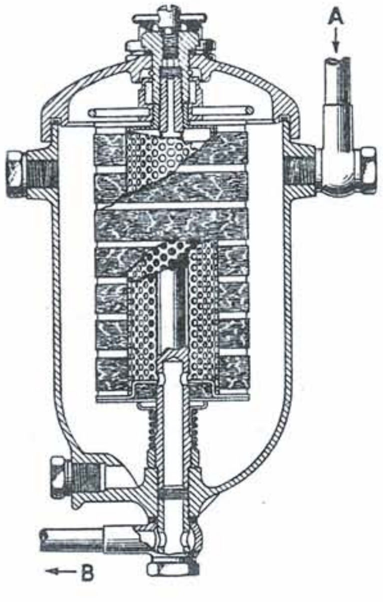


Fig. 34 *Fuel Filter—Felt pad design*

(A) *Inlet for fuel* (B) *Outlet to pump*

48. **OVERFLOW TUNDISH.**—Fig. 33. On the larger engines a tundish L is provided, and connected to the heater by the pipe P. The pipes leading to this tundish are a vent pipe M from the heater, a relief pipe N from the sprayer, and the return pipe O from the control valve. Fuel should always be issuing from this pipe when the engine is working.

On the smaller type engine the spill from the sprayer is taken to an oil pot attached to the sideshaft bracket, on monobloc engines the spill is taken back to the fuel tank.

FUEL PUMPS

49. **FUEL PUMPS.**—The engineer in charge should make sure which type of pump is fitted on the engine and work to the appropriate sections.

> **Paragraph No. 50 apply to HD4 to HH7 and IHD4 to IHH7 engines with a valve design pump.**
>
> **Paragraph No. 51 apply to HH8 to HH14 and IHH8 to IHH14 engines with a valve design pump.**
>
> **Paragraph No. 52 apply to monobloc engines with a valve design pump.**
>
> **Paragraph No. 53 apply to IHH8 to IHH10 engines with port controlled pump.**
>
> **Paragraphs 54 to 63 apply to all types of fuel pumps.**

50. **FUEL PUMP.—Valve design for Single Cylinder Engines—Fig. 35.**—Keep the pump scrupulously clean. Wash the pump, plugs and valves in clean paraffin before assembling. The valves seldom require grinding-in, but when necessary grind as little as possible. Where ball valves are used they seldom require attention, if they should leak when the seats are perfectly clean, **lightly** tap the balls on to their seats, using a soft brass or copper rod. Adjust the slotted nuts at the top of the control valve rod so that the clearance between the bottom of the rod and the thick part of the governor wedge **does not exceed 0.010 inch (0.26 mm.)** when the roller is on the back of the cam. Excessive clearance will cause the engine to race when the load is thrown off. There is no packing on the pump plunger. Any leakage is prevented from falling into the lubricating oil below by being led into a trough under the toe of the oil pump lever, from which a pipe leads away to the overflow oil pot. When any excessive leakage is noticed from the pump plunger examine the fuel sprayer nozzle because the holes may be obstructed and thus creating an excessive pressure in the system.

The fuel pump cam boss D2 is keyed to the sideshaft, and the fuel pump cam E1 is driven by studs E2 which are fixed in the cam boss. At the works a packing piece F1 is fitted between one of the studs E2 and the end of its slot in the cam to prevent slip, and to enable the cam to be replaced in the same position after dismantling. Always replace the packing in the same slot. When it is necessary to alter the pump timing, a thicker packing F1 gives earlier and a thinner packing later injection. Do not alter the packing more than $\frac{1}{32}$ inch (0·80 mm.) at a time, and never alter without very good reason and expert advice. Too much advance will cause very high pressures in the cylinder; too late injection loss of power and dirty running.

The lift of the delivery valve and of the top suction valve is $\frac{1}{64}$ inch (0·39 mm.). Too much lift may cause irregular ignitions, which would lead to a carbonised piston and sticking rings. The lift can be corrected by using a washer of different thickness under the valve plug. **Carborundum must not be used for grinding valves,** grind in very lightly with metal polish. Each valve must be returned to its own seat after examination and not interchanged with another valve. **Attend to one valve at a time** and do not let the valves become mixed.

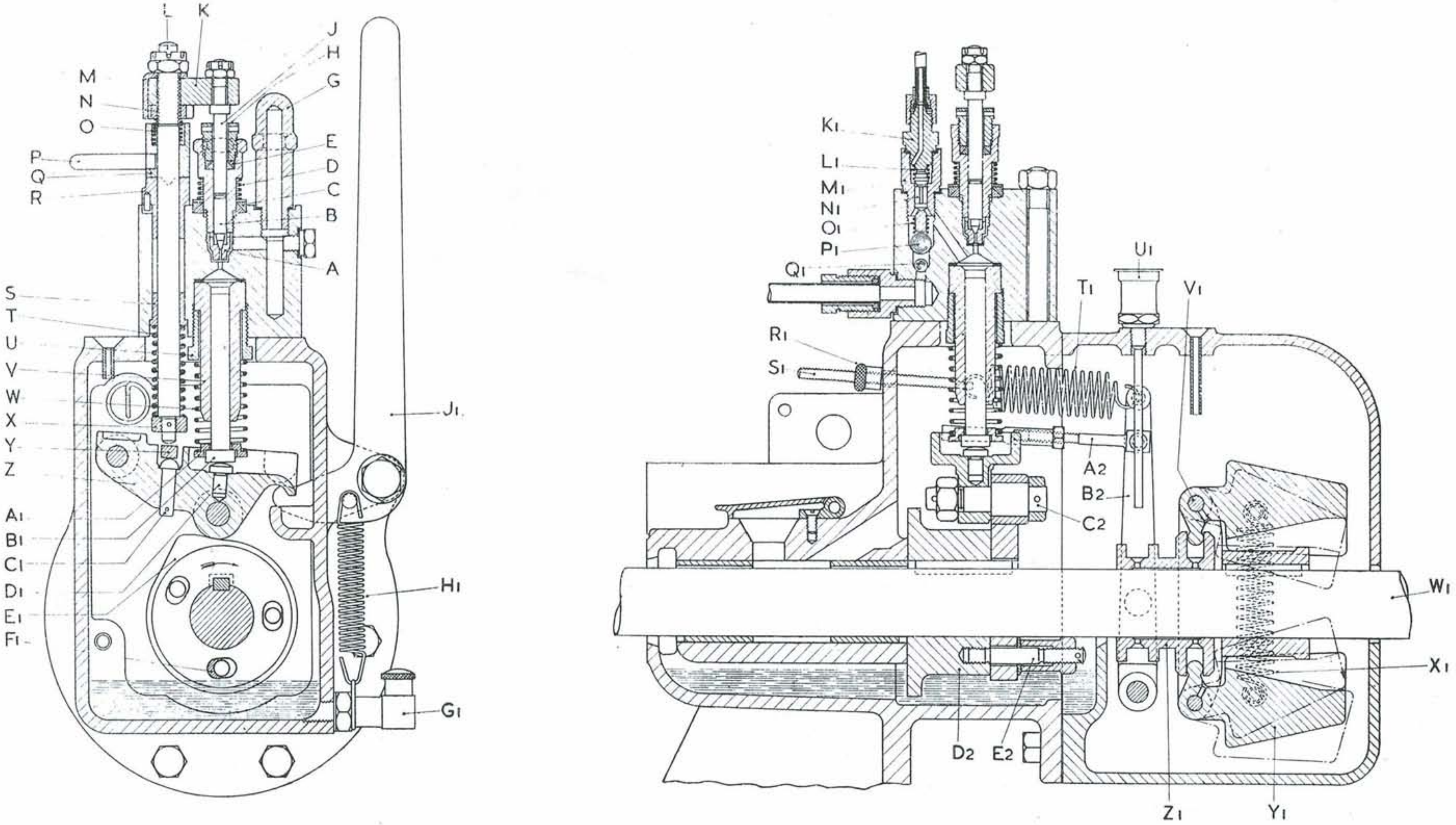


Fig. 35 *Fuel pump and sideshaft governor gear—as fitted on the smaller engines*

(*a*) *Control valve seat*
(*b*) *Control valve*
(*c*) *Packing ring for control valve seat*
(*d*) *Spring for packing ring*
(*e*) *Packing ring for control valve extension*
(*g*) *Air vessel*
(*h*) *Gland nut for control valve*
(*j*) *Control valve extension*
(*k*) *Connecting link*
(*l*) *Control valve rod*
(*m*) *Locking plate*
(*n*) *Adjusting nut*
(*o*) *Cut-out spring*
(*p*) *Cut-out handle*
(*q*) *Pump cut-out*
(*r*) *Top bush for rod*
(*s*) *Bottom bush for rod*
(*t*) *Spring for control valve rod*
(*u*) *Nut for barrel*
(*v*) *Fuel pump barrel*
(*w*) *Fuel pump spring*
(*x*) *Collar*
(*y*) *Governor wedge*
(*z*) *Fuel pump lever*
(*a*1) *Collar*
(*b*1) *Fuel pump plunger*
(*c*1) *Pin*
(*d*1) *Pad*
(*e*1) *Fuel pump cam*
(*f*1) *Packing piece for cam stud*
(*g*1) *Oil level gauge*
(*h*1) *Spring for handle*
(*j*1) *Fuel pump handle*
(*k*1) *Delivery valve plug*
(*l*1) *Delivery valve spring*
(*m*1) *Delivery valve plug*
(*n*1) *Delivery valve*
(*o*1) *Suction valve spring*
(*p*1) *Large suction ball valve*
(*q*1) *Small suction ball valve*
(*r*1) *Adjusting nut for speeder spring*
(*s*1) *Rod for speeder spring*
(*t*1) *Speeder spring*
(*u*1) *Lubricator*
(*v*1) *Governor weight pin*
(*w*1) *Sideshaft*
(*x*1) *Governor weight spring*
(*y*1) *Governor weight*
(*z*1) *Governor sleeve*
(*a*2) *Governor rod*
(*b*2) *Governor lever*
(*c*2) *Roller pin*
(*d*2) *Fuel pump cam boss*
(*e*2) *Fuel pump cam stud*

The packing of the control valve extension must receive careful attention; it consists of special rings. Screw up the gland nut so as to just touch the rings and no further; if excessive pressure is put on the ring it will cause the spindle to stick.

51. **FUEL PUMP.—Valve design for Single and Double Cylinder Engines—Fig. 36.** —The pump is operated by a lever J by the cam on the sideshaft. The pump cam consists of three parts: a boss T keyed to the sideshaft; a disc S secured to the boss by studs and dowels; and a toe piece K of hardened steel secured to the disc by the dowel C1, and cotter A1. The lower part of the cam runs in an oil bath.

A relief valve is situated in the pump body under the lower suction valve. By unscrewing this it can be ascertained that the fuel is flowing freely from the heater to the pump.

The fuel is forced through the sprayer into the combustion chamber by the fuel pump, **in fact the successful working of the engine depends almost entirely upon the pump, sprayer and control valve.**

Attention must be paid to the packing round the plunger B1, as special packings are used.

When repacking, first place the ring Y in position and behind this the rings G. See that these are put in the right way. Put in the gland F and screw the nut E down so as to press lightly on the rings to prevent them moving when the plunger is working.

Wash the valves, plugs and body in clean paraffin thoroughly before assembly. The valves seldom require grinding-in, but when necessary **grind as little as possible.** When the seats are satisfactory examine the lift of each valve; this must be $\frac{1}{32}$ in. (0·8 m.m). The satisfactory working of the engine depends to a large extent on the valves.

The lift of the valves can be corrected by adjusting the thickness of the washers under the plugs.

Carborundum must not be used for grinding valves, grind in very lightly with metal polish. Each valve must be returned to its own seat after examination, and not interchanged with another valve. **Attend to one valve at a time,** and do not let the valves become mixed.

52. **FUEL PUMP.—Valve design for Monobloc Engines—Fig. 37.**—Maintenance is principally limited to the efficient seating of the suction and delivery valves and the fit of the plunger B1 in its guide.

The lift of the suction ball valves L is 0·060 inch (1·524 mm.) and the lift of the delivery valve D is 0·060 inch (1·524 mm.). The lifts can be tested by placing a thin piece of sheet lead on top of ball valve and screwing down plug into position. Thickness of impression represents the valve lift.

To Test each Pump for Tightness.—With pump cam roller on cam base circle operate the priming lever slowly, and if the valves and plunger are tight the pump will feel "solid" and offer considerable resistance. On the other hand if the pump feels "soft," then this proves that fuel is escaping either past the suction ball valves, control valve, pump spindle, or the fuel sprayer nozzle.

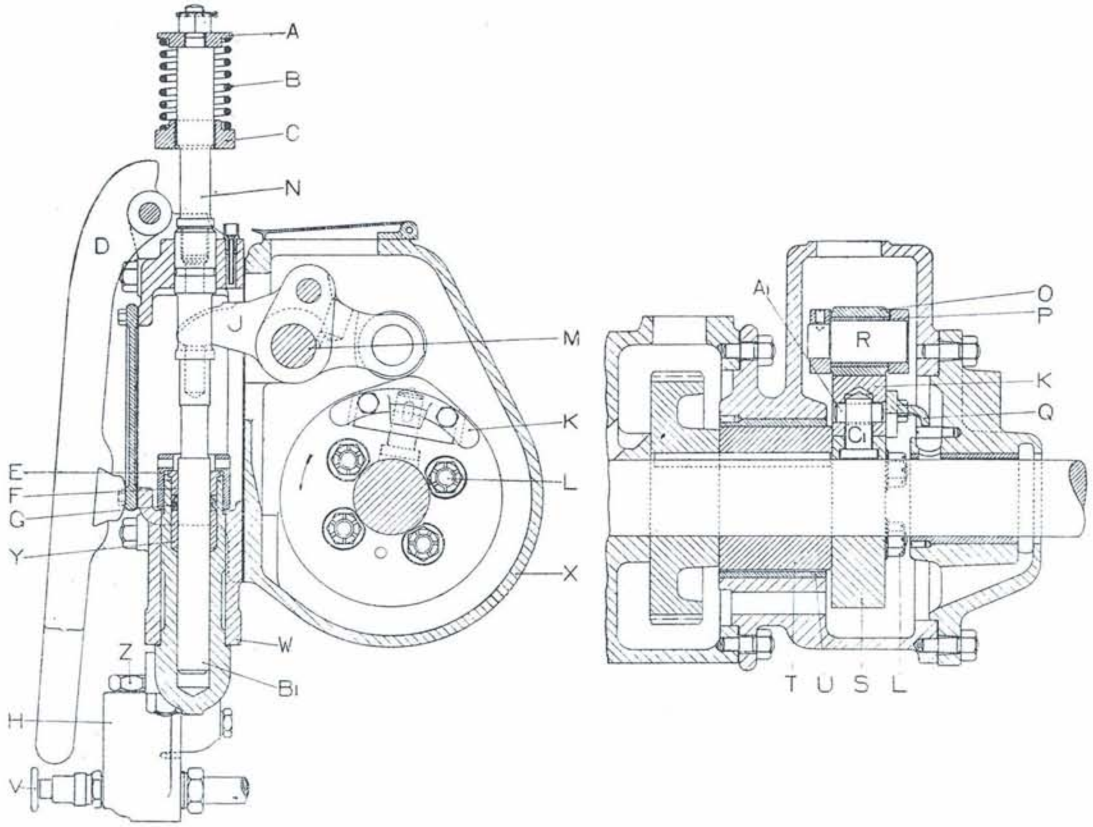


Fig. 36 *Fuel pump—as fitted to medium powered single and double cylinder engines*

(*a*) *Collar*
(*b*) *Spring*
(*c*) *Bridge piece*
(*d*) *Priming handle*
(*e*) *Gland nut*
(*f*) *Gland*
(*g*) *Gland packing*
(*h*) *Pump body*
(*j*) *Lever*
(*k*) *Toe piece for cam*
(*l*) *Disc studs*
(*m*) *Fulcrum pin*
(*n*) *Extension rod for plunger*
(*o*) *Roller*
(*p*) *Bush*
(*q*) *Oil catcher and keep plate*
(*r*) *Roller pin*
(*s*) *Disc*
(*t*) *Cam boss*
(*u*) *Bearing*
(*v*) *Drain valve*
(*w*) *Fuel pump guide*
(*x*) *Fuel pump bracket*
(*y*) *Gland ring*
(*z*) *Plugs over valves*
(*a1*) *Cotter*
(*b1*) *Fuel pump plunger*
(*c1*) *Dowel*

In order to determine whether the defect lies in the pump or sprayer, first remove the sprayer from cylinder and couple to pump with a test pipe; if there is no escape past the nozzle, then the fault lies in the pump. To isolate the defect in pump, first drain off fuel from the pump.

Proceed as follows :—

(a) Remove suction ball valve L and examine seating and ball valves for any foreign substance between valve and its seating, replace valves and again apply the pump test, and if the pump is not then tight, proceed to the next test.

(b) **Control Valve.**—Remove the control valve F and examine valve and its seating and if these are worn or defective replace with a new control valve and guide. Re-test pump and if still not tight, then the leak must take place past the only other source of exit, namely, the fuel pump plunger.

(c) **Pump Plunger.**—Any leakage past the plunger B can be ascertained easily whilst the engine is running, leakage being visible through the side of the pump casing, and if this is more than normal a new plunger and guide should be fitted. A new plunger must not be fitted to an old guide as these two parts are always lapped together.

(d) **Delivery Valves.**—A defective seating on the valve D whilst having no effect on tightness of the fuel pump will cause defective spraying.

(e) **Copper Joints.**—Whenever a washer is removed from the pump, it should not be used again; use a new washer.

(f) **Dismantling and Re-erection.**—Whenever the pump is dismantled, it is important the components of each pump be replaced on the pump from which they were abstracted.

Paragraphs 54 to 63 cover all types of fuel pumps.

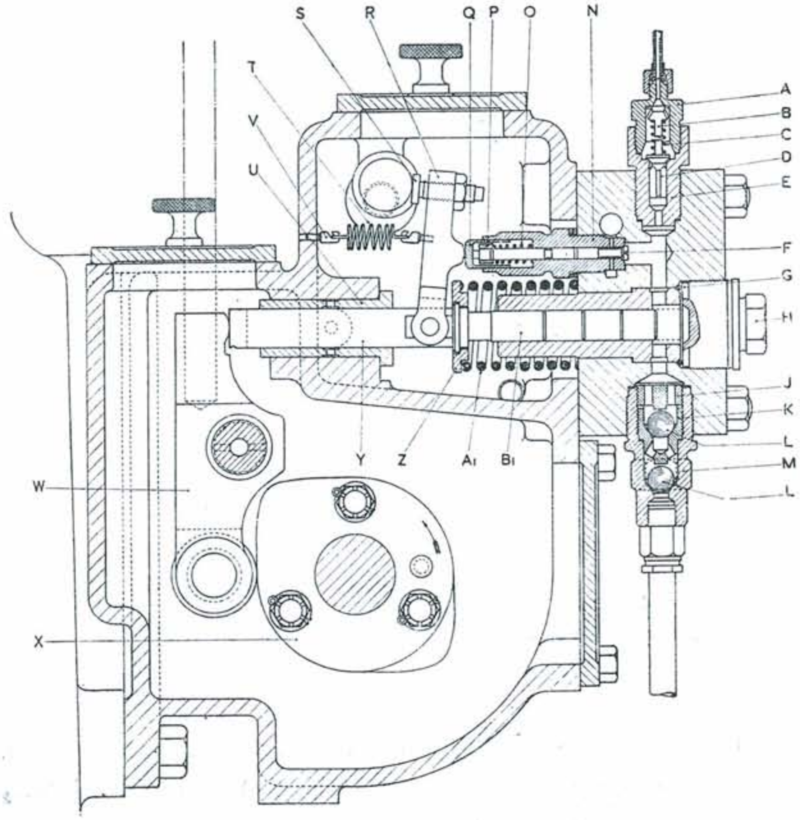


Fig. 37 *Fuel pump—double cylinder monobloc engines*

(a) Delivery union
(b) Delivery valve stop
(c) Delivery valve spring
(d) Delivery valve
(e) Delivery valve plug
(f) Control valve
(g) Joint ring
(h) Joint plug
(j) Suction valve stop
(k) Suction valve plug
(l) Suction ball valves
(m) Suction union
(n) Control valve guide
(o) Control valve spring
(p) Spring collar
(q) End piece
(r) Control valve pecker
(s) Adjusting screw
(t) Pecker spring
(u) Bush
(v) Hooks
(w) Rocking lever
(x) Fuel pump cam
(y) Plunger tappet
(z) Spring collar
(a1) Plunger spring
(b1) Pump plunger

53. **FUEL PUMP.—Port controlled design for Single cylinder Engines—Figs. 38 and 39.**—The pump plunger M and control valve spindle V are both actuated from the pump cam U1. The control valve spindle is operated by the fuel pump lever O in conjunction with the governor wedge Y.

The plunger M draws in fuel through the suction port E1, which remains open until the plunger closes the port on the upward stroke. Fuel is then delivered past the non-return delivery valve E. The control valve opens the by-pass port Z and some fuel is returned to the suction side of the pump.

The volume of fuel delivered to the fuel sprayer is determined by the effective delivery stroke of the plunger, that is the portion of the stroke after the closing of the suction port E1 and before the opening of the port Z.

The point at which the port Z is opened is determined by the clearance between the bottom of the spindle V and the governor wedge Y; increasing the clearance delays the opening and allows more fuel to be delivered.

The governor wedge Y decreases or increases the clearance as the governor weights Y1 move outward or inward, thus the governor controls the amount of fuel delivered. The amount of fuel injected depends not only on the setting of the control valve spindle, as determined by the clearance between the bottom of the spindle and the governor wedge, but also on the height of the fuel pump plunger M. When the plunger is set high it will close the suction ports earlier, delivery will in consequence commence earlier. This—with equal governor wedge clearance—will give a longer effective delivery stroke than if the plunger were set lower.

An air vessel U is fitted on the delivery side.

The fuel pump handle K1 has three functions, namely :

(a) Priming the fuel system.

(b) Testing the sprayer.

(c) To assist in the stopping of the engine.

Governor Wedge Clearance—The clearance is set at the works and should not require adjustment except **when the pump gear has been dismantled**; the following procedure is recommended :—

> Take off the top half of the governor bracket O1 and turn the crankshaft round until the nose of the fuel pump cam is pointing downwards, move the weights Y1 outwards until the distance between the centres of the governor weight spring pins J2 is 4·3125 inches (109·5 mm.). In this position the wedge should just make contact with the control valve V. Should the wedge fail to make contact with the control valve, or lifts the valve slightly this can be adjusted by washers H1 under the pin C1.

Fuel Pump Plunger Height—This should not be altered without the use of an indicator for measuring the maximum firing pressure of combustion in the cylinder.

When the original setting has been lost, the plunger height can be set approximately correct, before using the indicator, by a depth gauge AA and BB which should be used as follows :—

(a) Unscrew the fuel pump delivery valve body C and place the gauge block AA over the plunger.

(b) Rotate the crankshaft until the plunger is at the bottom of its stroke. The gauge spindle BB should be inserted through the block down on to plunger M, and the height should be such that a feeler gauge can be inserted between the top of the gauge block and the underside of the gauge spindle head. The **average** thickness of feeler gauge which is used as basis of adjustment is 0·031 inch (0·8 mm.).

(c) The height can be altered by adjusting the shims C2. It is important that after any dismantling operation these shims are replaced on re-erection otherwise the port timing will be affected.

Lubrication—The governor sleeve Z1, pins Q1 and J1 are lubricated from the lubricators P1 and O2 which should be replenished **daily.**

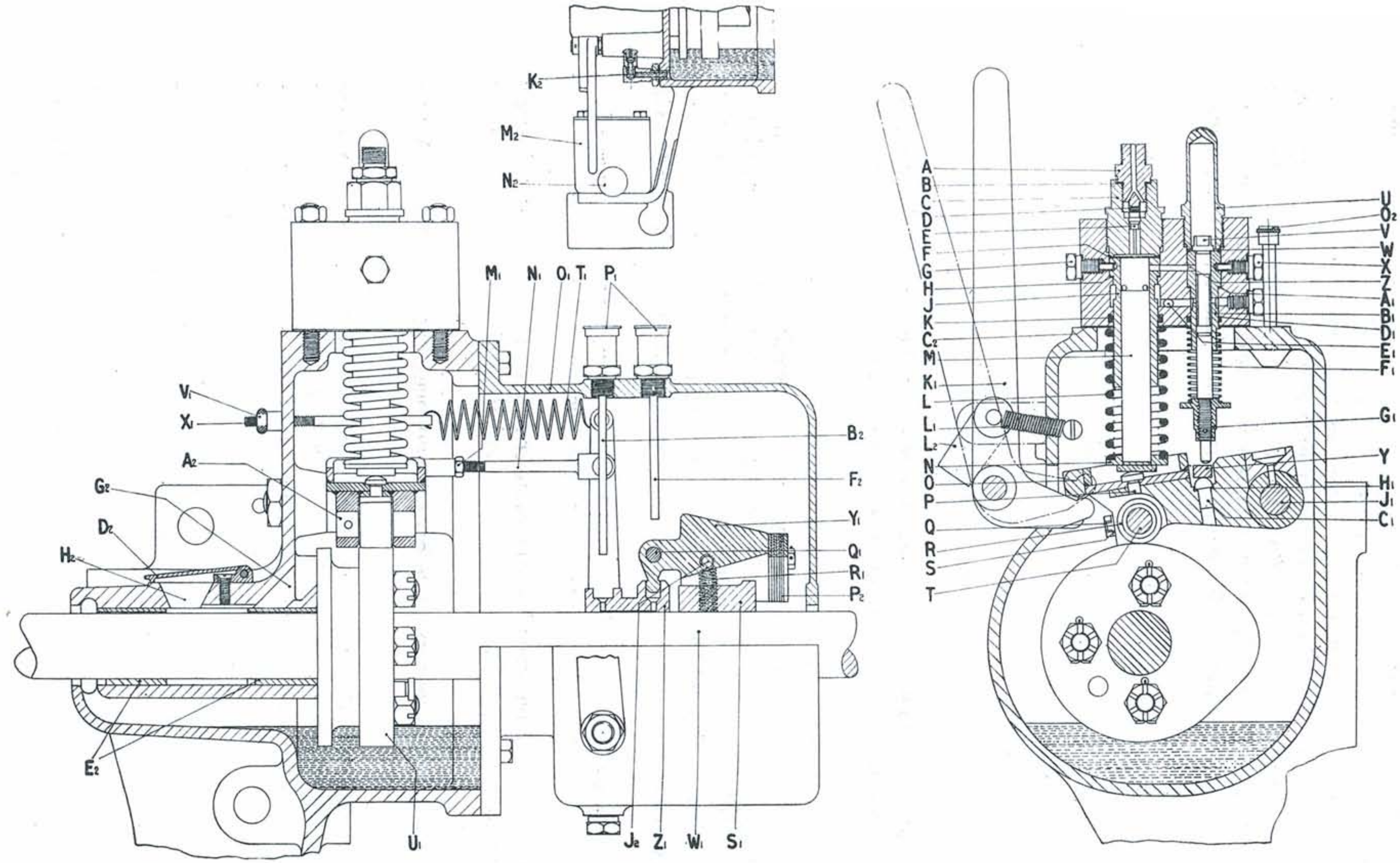


Fig. 38 *Fuel Pump—Port Controlled Design*

(A)	*Delivery valve plug*	(R)	*Fuel pump roller*	(H1)	*Washers for adjustment*	(Y1)	*Governor weight*
(B)	*Washer for delivery valve plug*	(S)	*Locking plate*	(J1)	*Fuel pump lever pin*	(Z1)	*Governor sleeve*
(C)	*Delivery valve body*	(T)	*Fuel pump roller pin*	(K1)	*Priming lever*	(A2)	*Roller pin*
(D)	*Delivery valve spring*	(U)	*Air vessel*	(L1)	*Spring for priming lever*	(B2)	*Governor lever*
(E)	*Delivery valve*	(V)	*Control valve spindle*	(M1)	*Locknut*	(C2)	*Shims for pump block*
(F)	*Joint ring for barrel*	(W)	*Joint for air vessel*	(N1)	*Governor rod*	(D2)	*Oil well lid*
(G)	*Locking screw for barrel*	(X)	*Locking screw for guide*	(O1)	*Governor casing*	(E2)	*Sideshaft bracket bushes*
(H)	*Joint for barrel*	(Y)	*Governor wedge*	(P1)	*Lubricator*	(F2)	*Lubricator feed pipe*
(J)	*Fuel pump barrel*	(Z)	*Port in control valve guide*	(Q1)	*Governor weight pin*	(G2)	*Lubrication passage*
(K)	*'O' Ring for barrel*	(A1)	*Joint for control valve guide*	(R1)	*Governor weight spring*	(H2)	*Oil well hole*
(L)	*Fuel pump plunger spring*	(B1)	*Control valve guide*	(S1)	*Governor weight carrier*	(J2)	*Governor weight spring pins*
(M)	*Fuel pump plunger*	(C1)	*Pin for fuel pump lever*	(T1)	*Speeder spring*	(K2)	*Oil level gauge*
(N)	*Plate for plunger spring*	(D1)	*'O' Ring for guide*	(U1)	*Fuel pump cam*	(L2)	*Stopping lever*
(O)	*Fuel pump lever*	(E1)	*Suction port*	(V1)	*Adjusting nut*	(M2)	*Fuel drain pot*
(P)	*Pad for fuel pump lever*	(F1)	*Control valve spring*	(W1)	*Sideshaft*	(N2)	*Drain tap*
(Q)	*Locking screw*	(G1)	*Nut for control valve spring*	(X1)	*Rod for speeder spring*	(O2)	*Lubricator*
						(P2)	*Lead weights*

The fuel pump cam U1 runs in an oil bath which is replenished through the oil well hole H2 in the sideshaft bracket. Oil splash lubricates the pump lever mechanism also the sideshaft bearings E2 by way of the passage G2. The oil level gauge K2 should be checked **daily.**

Starting prop—Fig. 40.—When a starting prop is fitted to the governor casing O1 to limit the amount of fuel injected at starting, make sure the prop R2 is in contact with the starting lever Q2 on the governor lever fulcrum pin. As the engine increases in speed the prop falls out of action.

Stopping—To stop the engine open the sprayer relief valve S, Fig. 49. An alternative method of stopping is to pull back the priming handle K1, Fig. 38, and move the lever L2 into position against the pump casing to maintain the handle in the "stop" position.

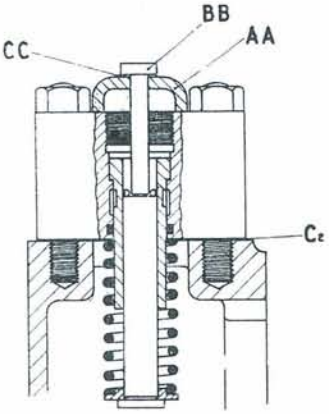


Fig. 39 *Fuel Pump Plunger Setting*

(C2) *Shims for pump block*
(AA) *Block for depth gauge*
(BB) *Depth gauge spindle*
(CC) *Feeler gauge of required thickness to be inserted here*

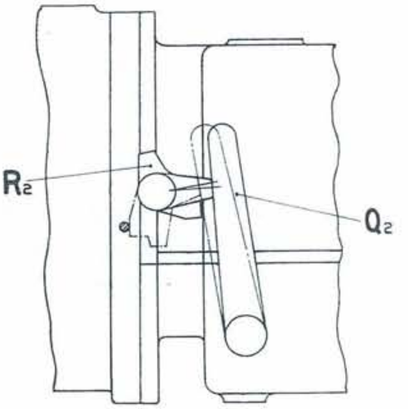


Fig. 40 *Starting Prop*

(Q2) *Starting lever*
(R2) *Starting prop*

54. **FUEL PUMP CAM.—Fig. 41.**—To adjust the cam to alter the injection timing, first withdraw the end cover on the pump bracket. Then remove the pins in the nuts E, slack back the nuts and remove the steady pin L. The cam disc A can then be moved a little either backwards or forwards. The steady pin is fitted after the best setting for the fuel injection has been found for Class "A" fuel, and this setting should not be altered without good reason.

When using a light fuel, or if the ignition tends to be noisy, the cam may be adjusted by setting it a little later, by moving it slightly in a clockwise direction. When a heavier and more viscous fuel is used, or if the exhaust shade tends to be black, the cam may be adjusted by setting it a little earlier, that is to say, by moving it in a counter-clockwise direction (see arrows below the cam disc).

The advancing of the timing must be considered only as the last thing to do to improve the working of the engine. Before making this alteration we recommend users to write for advice, giving **full particulars** of the fuel, and stating why they suggest making any change.

A very small movement from the position fixed by the steady pin makes a considerable difference in the timing of the fuel injection.—It is necessary to be very careful in making changes, and the best method is:—Replace the pin L in the position as found; remove the nut from one of the studs E and measure very carefully the distance from the edge of the stud to the edge of the slot, Fig. 41. Then remove the pin L and adjust the cam disc for either earlier or later injection (see arrows). **Never move the disc at any one adjustment more than will alter the distance from the edge of the stud to the ends of the slot by more than 1/32 in. (say 1 mm.),** which is equivalent to changing the point of injection about two degrees on the path of the engine crankpin.

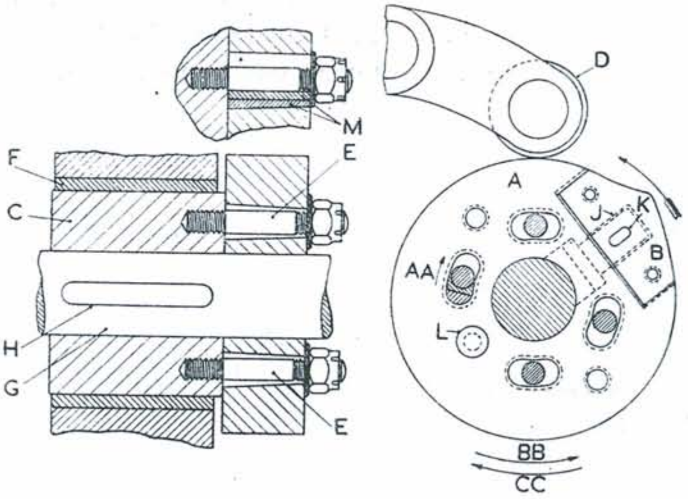


Fig. 41 *Adjusting the timing of the cam*

(*a*) *Pump cam disc*
(*b*) *Cam toe piece*
(*c*) *Cam boss*
(*d*) *Pump cam roller*
(*e*) *Cam studs and nuts*
(*f*) *Bronze bush*
(*g*) *Sideshaft*
(*h*) *Key*
(*j*) *Dowel pin for toe piece*
(*k*) *Cotter for dowel*
(*l*) *Steady pin fitted after test*
(*m*) *Packing pieces to be used when time of injection is altered*
(*aa*) *Pressure on stud*
(*bb*) *Earlier fuel injection*
(*cc*) *Later fuel injection*

After alteration it will be impossible to re-insert the steady pin, a packing piece (or two packing pieces) should be inserted between one stud and the end of its slot as shown in Fig. 41. These should be fitted so as to bed on the whole length of both the stud and the end of the slot. Screw up all the nuts **securely,** and be sure to replace all the split pins.

This procedure should be carried out each time a change is made. If the packing pieces are not inserted after an alteration, there is a possibility of the disc slipping, and the injection becoming much too late.

55. DISMANTLING OF FUEL PUMP CAM.

(a) **To dismantle the Cam.**—Proceed as described for adjusting the setting. When the pin and the nuts are removed, the disc can be drawn along the shaft if screws are screwed in the two holes in the disc.

(b) **To Dismantle the Toe Piece.** Should this be necessary, **and not unless,** drive the cotter K out, in the direction from left to right when looking at Fig. 41. The toe piece can then be lifted by a thin wedge.

Care must be taken when assembling to see that the toe piece beds firmly on the disc, that the cotter is tight, and that when the nuts have been tightened up, the split pins are not omitted. It is extremely important that when replacing the toe piece, the periphery of the disc exactly coincides with both ends of the toe piece. Should the toe piece be removed it must be re-inserted the correct way round.

Important.—On sizes HH8 to HH14 and IHH8 to IHH14 the toe piece should be in such a position that the holes for the oil catcher plate in one side are on the side nearest the crankshaft.

56. **COMPRESSION PRESSURE.**—Before adjusting the maximum cylinder firing pressure the compression pressure must first be correct; the actual pressure can be measured with an indicator.

The compression will be approximately correct when the bumping clearance between the piston crown and breech end as tested by lead wire impression is as quoted in the technical data. The resulting pressure will be substantially correct for an engine operating under normal atmospheric conditions.

The compression pressure is varied by the plates placed between the connecting rod and large-end bearing, excepting where the connecting rod is of the fixed centre design.

The compression pressures may vary slightly on double cylinder engines from cylinder to cylinder and can be said to be out of balance when there is a difference of approximately 20 p.s.i. (1.41 kg. per cm.^{2}) between the highest and lowest reading.

57. **MAXIMUM CYLINDER FIRING PRESSURE.**—The fuel injection timing should be set to give the firing pressure **not exceeding** that given in technical data.

This checking should be done every **2,500 hours** on each cylinder, or whenever any part of the operating mechanism is replaced.

58. **FUEL PUMP VALVES.**—All valves should be kept in perfect order, the effect of a faulty valve will be to upset the cylinder balance on double cylinder engines and the exhaust temperatures. When these symptoms are found, and provided that the fuel sprayers are in order, there are two tests which can be applied:—

(a) With the delivery valve unit in position and the sprayer pipe disconnected, the hand priming lever can be operated so that the fuel is pumped past the valve and through the delivery connection. The priming lever should then be operated very carefully. When the valve is faulty it will be found that on the suction stroke of the pump the fuel level will drop, showing that the fuel is being sucked back into the pump. When the valve is seating perfectly there will be no tendency for the fuel to be sucked back.

(b) Alternatively the delivery valve and body may be removed and the valve subjected to air pressure through the discharge connection whilst the body is immersed in water. Leakage will be shown by air bubbles from the underside of the valve.

The valves seldom require grinding-in, when this is necessary they should be **ground in as little as possible.** Before grinding-in make sure the springs are in good condition. Broken or worn springs must be replaced.

To grind in a delivery valve, fit the special holder over the projection on the valve head, and grind in very lightly with metal polish. When the seating is in satisfactory condition re-examine each delivery valve lift. Spreading of the top pip on the valve or stop should be rectified; defective parts should be immediately replaced.

The delivery valve stops are subject to wear, and need to be checked periodically by visual inspection or by measuring the valve lift.

Worn stops seriously upset the fuel injection, and must be replaced by new ones. Take care to reset the valve lift to the correct figure.

Some fuels may tend to leave a tarry deposit on the valves which should be cleaned off, its presence indicates that a too viscous grade of fuel is being used, or the fuel temperature is too low.

59. **FUEL PUMP ROLLERS AND CAMS.**—In exceptional cases the pump rollers may develop flats because of not rotating correctly, or fuel pump cams may wear. It will be understood that such an occurrence will seriously interfere with correct fuel injection.

Periodic examination is recommended, and parts replaced immediately wear occurs.

An occasional check should be made to ensure that the fuel cam has not worked loose on its key.

No alteration to fuel pump timings must be made until the rollers and cams have been examined.

60. **ELIMINATING AIR FROM THE FUEL PUMP.**—After dismantling, air will be present in the system and must be eliminated before attempting to start the engine. Air collecting in the pump will result in irregular working and may tend to produce growths on the sprayer nozzle. The presence of air can be readily detected by testing the fuel pumps for solidity; if air is in the pump it will not be "solid,"—see paragraph 61.

The suction pipe should be examined for air leaks; the tiniest aperture will allow air to gain access into the pump. The union joints on the suction pipe should be carefully ground in to the connections to make sure these parts are making sound metal to metal joints.

At the same time examine all other joints in the fuel system after connecting up the suction pipe.

61. **TESTING THE FUEL PUMP FOR SOLIDITY.**—Every **200 hours,** or if fuel pump leakage is above normal, then the fuel pump line should be tested to see that the pump is "solid." Prime with the priming lever, so that all the air is eliminated. Then blank off the pump delivery; operate the priming lever and the pump should feel solid.

When the pump does not feel "solid" and all air in the pump has been eliminated, then fuel is leaking past either the control valve spindle, the pump plunger, or the copper washers in the pump are not in good condition.

In order to ascertain which is faulty, proceed as follows:—

(a) See that the fuel pump cam roller is on the back of the cam, i.e., the plunger is at the bottom of its stroke.

(b) Make sure that the control valve spindle is at the bottom of its stroke.

(c) Disconnect the fuel control return pipe at the fuel pump end, so that any fuel passing can be observed.

(d) With the fuel delivery on the pump still blanked off, work the priming lever with short strokes, so that the control valve spindle does not uncover the port.

When there is any fuel escaping at the control return, then the control valve spindle is not a satisfactory fit in its guide. These parts should be examined and if necessary renewed —see paragraph 63.

When there is no fuel escaping at the control return and the pump is not "solid," then the plunger is not a satisfactory fit in its guide, or the copper washer under the guide may be faulty—see paragraph 62.

62. **RENEWING THE FUEL PUMP PLUNGER AND BARREL.**—A damaged plunger or barrel must be renewed. It is not recommended to renew either plunger or barrel independently, as they are tested in pairs and should always be renewed together. When a new plunger and barrel have been fitted and if the plunger is found to be tight, then the barrel should be carefully tapped into and out of position in the pump body, and any high spots on the outside of the barrel removed by a fine grade stone. Should this method fail to free the plunger, it is permissible to lap the plunger into the barrel about 500 times, using chrome oxide and lubricating oil as a lapping medium.

The plunger must not be eased, or it will be ruined.

63. **RENEWING CONTROL VALVE SPINDLE AND GUIDE.**—A damaged spindle or guide must be renewed. It is not recommended to renew either spindle or guide independently, as they are tested in pairs and should always be renewed together. When a new control valve spindle and guide have been fitted and if the spindle is found to be tight, then the guide should be carefully tapped into and out of position in the pump body, and any high spots on the outside of the guide removed by a fine grade stone.

Should this method fail to free the spindle, it is permissible to lap the spindle into guide about 500 times, using chrome oxide and lubricating oil as a lapping medium. The control valve spindle must not be eased with a stone or it will be ruined.

64. **FUEL CONTROL VALVE—Fig. 42.**—On HH8 to HH14 and IHH8 to IHH14 single and double cylinder engines with a valve design fuel pump the control valve is operated from the governor by a tapered wedge. This valve returns a portion of fuel back to the heater during every delivery stroke of the pump plunger, the **quantity** thus released and the **time** of release being determined by the governor. A spring H ensures prompt closing of the valve. The fuel is delivered under pressure from the fuel pump and a slight opening of the valve places the inlet and outlet chambers into communication; the pressure falls and injection through the sprayer then ceases instantaneously.

It is imperative that this valve works freely. It should be quite clean, especially the seat, as if the valve does not return to its seat promptly, the fuel will leak past the seating instead of being delivered through the sprayer, and there will be a loss of power.

It is a simple matter to test the control valve for leakage. Prop the governor lever up in such a position that the thinnest part of the wedge comes opposite the control valve. Turn the engine so that the piston is at its outer end of the stroke, then close the sprayer relief valve and **put the pressure on the pump by the lever WITHOUT moving the pump far enough to open the control valve.** If any fuel is seen to pass into the tundish from the pipe leading from the control valve it is a sign that the valve is leaking.

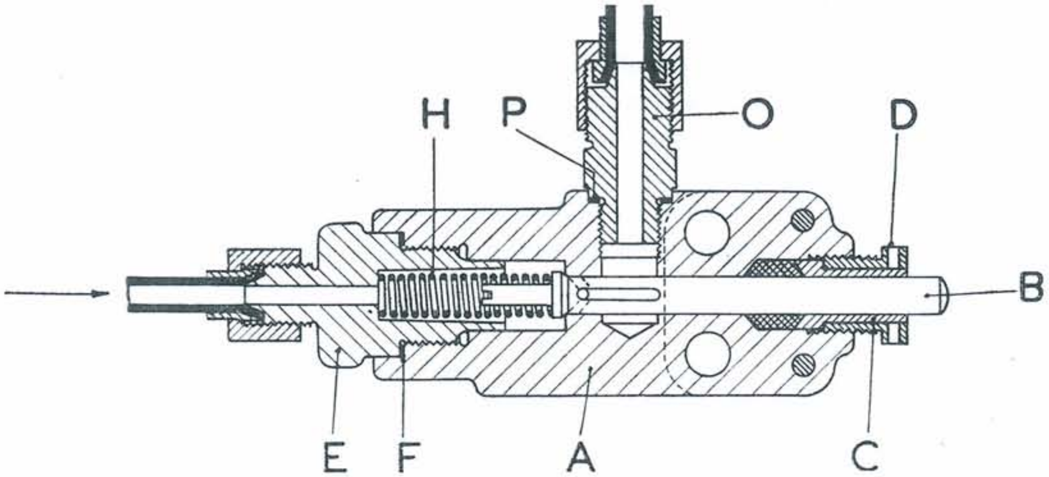


Fig. 42 *Control valve*

(*a*) *Valve body*
(*b*) *Valve spindle*
(*c*) *Valve front gland*
(*d*) *Front gland nut*
(*e*) *Union cap*
(*f*) *Washer for union cap*
(*h*) *Valve spring*
(*o*) *Union plug for outlet*
(*p*) *Washer for outlet plug*

The gland must be efficiently packed with soft "Palmetto" packing, and not adjusted too tightly. Place one of the separate packing coils in the stuffing box, wrapping it loosely round the spindle. Press each coil down into place, taking care that each coil is home before another is pressed hard behind it. Whilst doing this, work the valve up and down and also rotate to see that it is quite free. If a leaky seating is suspected, the spindle may be slightly ground in. **As little grinding as possible** should be done.

65. **CONTROL VALVE MECHANISM.**—(a) **Single and Double Cylinder Engines.**—Fig. 43. The control valve A is actuated by the pecker bolt B fixed in an extension of the pump lever C. The wedge D, attached to the governor lever by the rod E, is interposed between the setscrew F in the pecker bolt B and the end of the valve A. The governor raises or lowers the wedge D and the amount and time of opening of the valve A is varied to suit the load.

If it is necessary to use a new pecker bolt it is important that position of the latter should be correctly fixed and when the roller on the pump lever is quite clear of the cam. The thicker portion T and Y of the wedge should be **only just able to pass freely** between the head of the pecker bolt and the end of the control valve, this clearance should not exceed 0·010 inch (0·254 mm.).

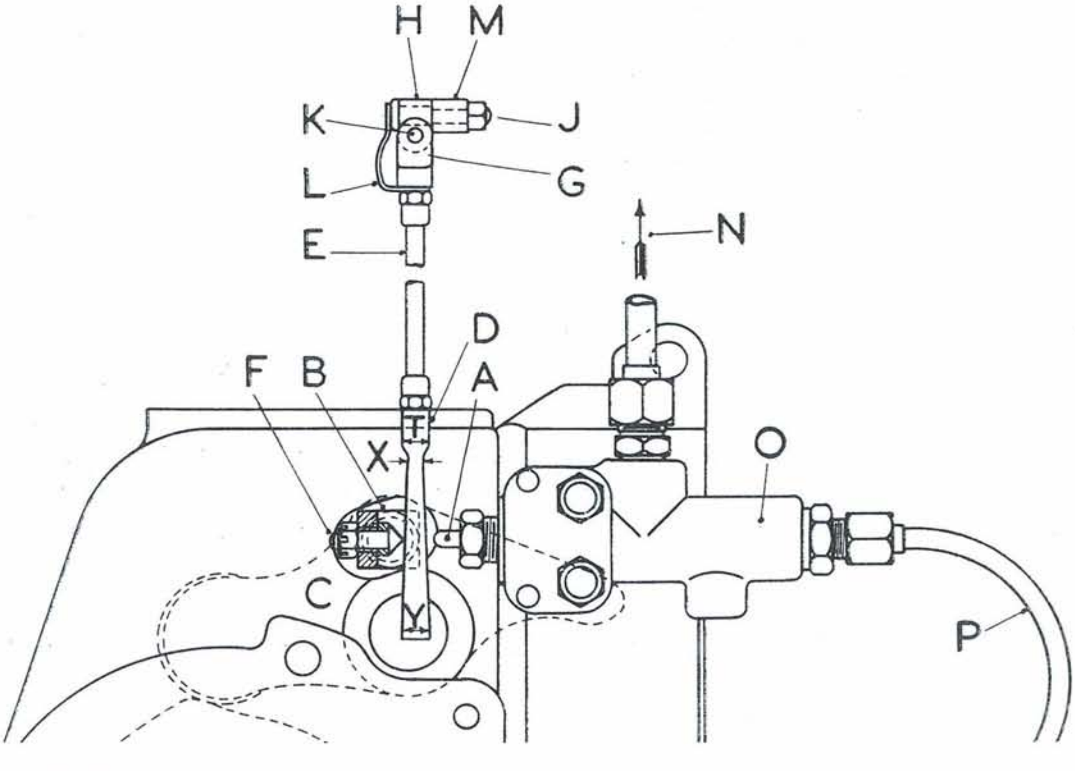
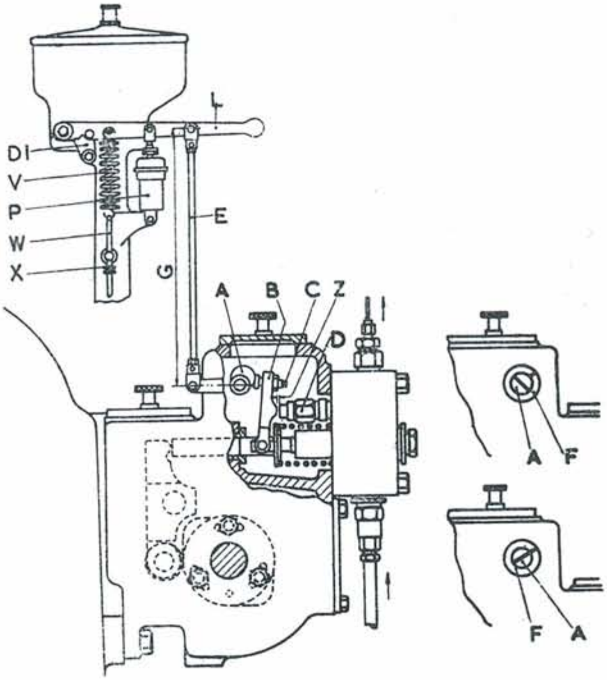


Fig. 43 *Control valve mechanism for single and double cylinder engines*

(*a*) *Control valve*
(*b*) *Pecker bolt*
(*c*) *Fuel pump lever*
(*d*) *Governor wedge*
(*e*) *Governor rod*
(*f*) *Pecker bolt striker*
(*g*) *Jaw for universal joint*
(*h*) *Eye for universal joint*
(*j*) *Fulcrum pin for universal joint*
(*k*) *Pin for universal joint*
(*l*) *Governor rod spring*
(*m*) *Governor lever*
(*n*) *Pipe to overflow tundish*
(*o*) *Control valve body*
(*p*) *Pipe from fuel pump*
(*t*) *Thickest part of wedge*
(*x*) *Thinnest part of wedge—overload*
(*y*) *Thickest part of wedge—no load*

(b) **Monobloc engines.**—Fig. 44. The length of governor rod E is fixed at the works and must not be interfered with. Setting lines are marked on the end of the governor eccentric shaft A and on the governor bracket facing F. Wedge up the governor lever L until these two lines are coincident as shown.

The approximate length of the governor rod, dimension G is 14.75 ins. (374.65 mm.) After test, the rod ends are drilled and pinned in position, and any alteration may result in the fuel pumps being placed outside the range of the governor.



(a) Governor eccentric shaft
(b) Control valve pecker
(c) Adjusting screw
(d) Control valve body
(e) Governor rod
(f) Governor bracket facing
(g) Length of governor rod—fixed at works
(l) Lever
(p) Governor dashpot
(v) Speed adjustment spring
(w) Tension rod
(x) Speed adjustment nut
(z) Pecker clearance
(d1) Starting prop

Fig. 44 *Control valve mechanism for double cylinder monobloc engines*

The clearance Z between pecker B should then be adjusted by this control valve lever screw C to 0·010 inch (0·254 mm.). Particular care should be taken to ensure that the fuel cam roller is on the cam base circle of the pump on which the adjustment is being made.

66. **RENEWAL OF JOINTS IN FUEL SYSTEM.**—Joints should be renewed as found necessary in service. Copper joint rings and washers removed when making renewals or adjustments, should be annealed before replacing except where it is specified they should be discarded.

FUEL SPRAYERS

The operator should note the type of sprayer fitted to the engine and then work to the appropriate paragraphs.

Long spindle type fuel sprayer for HD4 to HH7 type engines	paragraphs 76 to 78
Long spindle type fuel sprayer for HH8 to HH14 type engines	paragraphs 79 to 82
Short spindle type fuel sprayer for HD4 to HH14 and IHD4 to IHH14 type engines	paragraphs 83 to 85

67. The fuel sprayer is situated on the breech end with the nozzle end projecting directly into the combustion chamber. Atomisation is accomplished by forcing the fuel through fine holes in the nozzle under high pressure. The pressure is attained by the insertion of a spring-loaded differential valve spindle with its seating just above the sprayer holes. This spindle cannot lift until sufficient pressure has been developed to overcome the spring resistance. When the spindle lifts, fuel is admitted to the combustion chamber and the injection continues until the pump control valve opens. This immediately releases pressure and the sprayer spindle closes automatically.

Paragraphs Nos. 68 to 75 apply to all types of sprayers.

68. **OPERATION.**—The fuel from the pump is delivered to the sprayer strainer and thence to the nozzle. A relief valve S is fitted which, when opened, allows the fuel delivered from the pump to pass to the overflow tundish, Fig. 33, or drain pot thus stopping the engine. The sprayer consists of a body on the end of which is a nozzle B and cap A. The joint between the nozzle and body is made in the form of a coned seating. A seating is formed in the nozzle for the spindle D. The spindle is closed by the spring H and opened by the pressure of the oil from the pump, and its lift is limited by the stop L. When the spindle D is opened, fuel is sprayed into the combustion chamber until the control valve opens, when the spraying ceases.

69. **TESTING THE SPRAYER.**—After cleaning or re-assembling the sprayer, or if at any time the engine is lacking in power, or if the exhaust gas is dirty and the fuel consumption high, remove the sprayer and test it to see if the cause can be ascertained:—

Secure the sprayer to the delivery pipe with the nozzle pointing into the open air away from the engine. On larger type engines raise the governor lever on to the starting prop so that the control valve cuts out at each stroke of the fuel pump, and work the pump and see that there is no air in the system.

Inspect the spray carefully and check whether the sprayer dribbles—see paragraph 68. It is useful to place a piece of paper about 6 inch (150 mm.) away from the nozzle and then operate the priming lever. A clear imprint should be obtained on the paper, showing that all the jets are clear. If a jet is not showing, or is weak the corresponding hole in the nozzle should be cleaned. It is better to clean a partially restricted hole than to let it choke up.

The joints of the suction pipe, strainer, cock and heater are very important and must not allow air to leak in; any doubtful joint must be re-made.

A release screw is provided on the fuel pump, which, when opened, shows that the fuel is passing freely through the pump. Work the pump by means of the handle until it feels quite "solid." When there is no air in the fuel system each charge of fuel should be ejected in a fine spray which cuts off promptly, at the end of each stroke, when the control valve opens. **The sprayer should be tested with thin fuel.**

70. **CAUSE OF SPRAYER DRIBBLE.**—When there is a dribble it is a sign that either the sprayer spindle or the nozzle requires attention. Examine the following parts and correct the defect as found necessary:—

(a) **Nozzle.**—See that the seating of the nozzle B and the body C has not been damaged when dismantling. If it has the oil may leak past the joint and find its way out between the nozzle and cap. See paragraph 75.

(b) It is **not** intended that the spindle shall have a seating over the whole of the cone, but only at the edge, and not wide enough to reach to the edge of the sprayholes. All the parts must be thoroughly cleaned out and free from powder. Do not allow any powder to get up the spindle guide, therefore, never remove the spindle from the body when grinding-in, until the nozzle has first been removed and all the powder cleaned away. Carbon tends to fill up the space between the nozzle and cap. When taking the nozzle out any carbon must be scraped off the outside of the nozzle and from the inside of the cap before replacing either of them in position. Absolute cleanliness is necessary with all parts of the sprayer when putting them together.

(c) **Sprayer Spindle Gland for long spindle type sprayers.**—The spindle may not be working sufficiently freely in the gland. Examine for rust or corrosion. If in very bad condition renew both spindle and packing. Do not tighten the gland so as to cause the spindle to stick.

Make sure first, therefore, that the fault does not lie elsewhere. When testing, wipe the nozzle clean after each ejection, so as not to confuse any dribble.

Fuel will be seen to have been running down the face of the sprayer cap and breech end wall if the sprayer is dribbling.

71. **SPRAYER NOZZLE.**—The joint between the nozzle and the body is a metal to metal one, in the form of a cone seating, the surfaces of which have been lightly ground together.

It is extremely important that the accurate alignment of the sprayer spindle and seating in the nozzle is preserved.

The following instructions must be carefully observed:—

(a) Should a new nozzle be fitted at any time it may require to be lightly ground in on the cone seating with metal polish (not carborundum), and then finished off with white or red lead and oil. Probably no grinding-in will be required.

(b) Use only the special tool provided for screwing the nozzle cap into place. Do not use much force.

(e) When placing the nozzle in the body, **see that the "locating slot" in same is in line with the slot in the sprayer body.** Check this again when the nut has been tightened.

IMPORTANT.—All parts of the sprayer **must** be always perfectly free from grit and dirt. If the sprayer is not kept perfectly clean, imperfect spraying and bad combustion will result. Furthermore, if the sprayer is out of order it may dribble and cause carbonisation and high fuel consumption. The fuel will run down the combustion chamber wall and carbonise on the exhaust valve seating.

72. **SPRAYER STRAINER.**—The fuel is delivered to a strainer attached to the sprayer body, and continues downwards to the nozzle. It is important all fuel passes through the strainer. Clean any sediment from the strainer every **250 hours,** or more frequently if found necessary. See that any gauze strainer is free from holes, rents, and oxidisation; damaged gauze or porous metal strainers must be replaced. The edge type strainer is generally used.

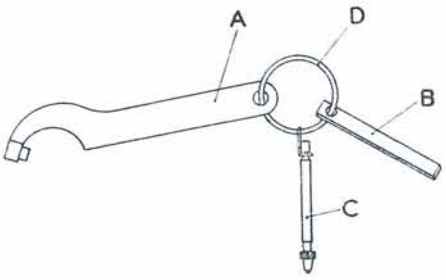
Each end of the edge type strainer spigots into the body whereas the outside diameter of the element between the spigoted end portions is smaller than the bore in the body. Incoming fuel flows along the grooves which are open at the pump end of the element but are sealed at the sprayer end. From these grooves the fuel has to pass through the 0·001 inch (0·0254 mm.) gap between the element and the strainer body into the grooves which are open at the sprayer end and sealed at the pump end. The gap acts as an efficient strainer; any foreign matter is retained in the grooves.

When removing the element the hexagonal portion should be gripped in a vice and strainer body slackened off with a spanner. Never grip the strainer body in a vice to slacken off the element.

When replacing the strainer element, make sure the washer is in good condition. The joint element ends should be examined to make sure they are not damaged.

73. **NEED FOR CLEANLINESS WHEN DISMANTLING.**—When cleaning the sprayer body, nozzle and spindle, they should be carefully washed in paraffin, and the small holes in the end of the nozzle cleaned out carefully with fine wire provided. Under no consideration must these holes be enlarged, as their size is of great importance. One or two holes are drilled in the plate gauge, see Fig. 45, to correspond to the sizes drilled in the nozzle. A wire or wires will be found in the container. This is a gauge and will be found to just pass into the hole or holes in the plate and nozzle. If the holes in the nozzle are appreciably larger than the holes in the plate gauge (which can easily be ascertained by trying the wire in both the plate and nozzle) the nozzle should be changed for a new one.

It is important that the sprayer should only be dismantled on a clean metal surface. The use of a sheet of paper or rag should be avoided. All tools for dismantling and paraffin required for cleaning the sprayer should be perfectly clean.



(*a*) *Sprayer cap spanner*
(*b*) *Plate gauge*
(*c*) *Holder containing poker wires*
(*d*) *Split ring*

Fig. 45 *Sprayer gauges*

74. **REPLACING SPRAYER INTO BREECH END.**—When fitting the sprayer in position care must be taken to see that the nuts are tightened up equally, so that no distortion takes place. Distortion will interfere with the proper working of the sprayer. The nuts should be screwed down a little at a time, first one and then the other, and not too tightly—this cannot be over-emphasised.

It is advisable to check the sprayer valve lift on long spindle type sprayers when it is finally in position.

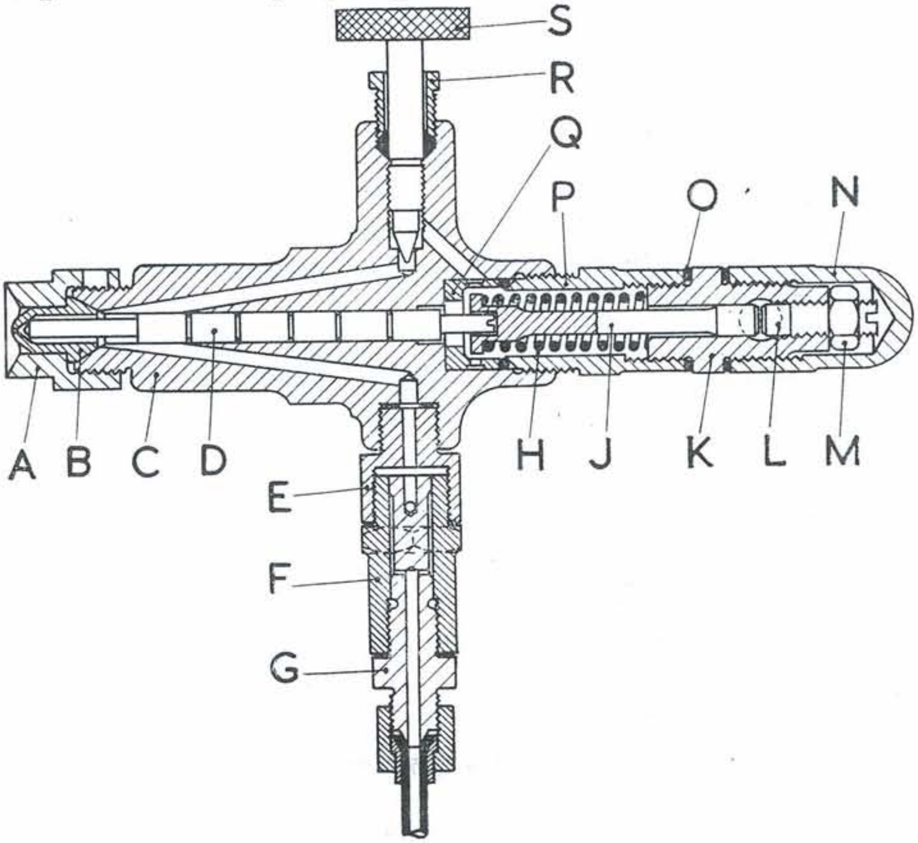
75. **LEAKAGE PAST SPRAYER SPINDLE SEATING.**—Should there be any fuel leakage through the nozzle holes, when the spindle is in position on its seat, the sprayer should be cleaned as described in paragraph 73. The accuracy and super-finish of the sprayer components is such that the operation of grinding-in by hand is not recommended, as this will damage the high finish and accuracy of the parts. Only in the event of damage to the seating surfaces may light grinding-in with metal polish be resorted to, until such time as the parts can be replaced with new ones.

When the fuel passing through the leakage pipe becomes excessive it is a sign that the spindle has become worn, and both spindle and guide should be renewed. It is not recommended that the parts be renewed independently.

Excessive fuel passing through the leakage pipe may also indicate that leakage is occurring at one of the lapped joint faces of the nozzle, guide, and body. These faces should be treated with care when the sprayer is dismantled, and should be kept clean. Leakage here may also result in fuel passing up the side of the sprayer.

Paragraphs Nos. 76 to 78 apply to HD4 to HH7 type engines fitted with long spindle type sprayers.

76. **FUEL SPRAYER.**—Fig. 46. It will be observed that the spindle D is located in the body C, whereas its seating is in nozzle B. It is **essential** that the nozzle seating is in correct alignment with the guide; this will be accomplished automatically by the **self-centring properties of the sprayer, provided all parts are correctly assembled.**



(*a*) *Sprayer cap*
(*b*) *Sprayer nozzle*
(*c*) *Sprayer body*
(*d*) *Sprayer spindle*
(*e*) *Adaptor for strainer housing*
(*f*) *Strainer housing*
(*g*) *Strainer element*
(*h*) *Sprayer spring*
(*j*) *Sprayer spindle extension*
(*k*) *Plug for sprayer cap*
(*l*) *Spring stop*
(*m*) *Nut for stop*
(*n*) *End cover*
(*o*) *Spring cap washer*
(*p*) *Spring cap*
(*q*) *Distance piece*
(*r*) *Gland nut for relief valve*
(*s*) *Relief valve*

Fig. 46 *Fuel sprayer—Long spindle type*

77. **LIFT OF SPRAYER VALVE.**—The lift of the spindle D is limited to the clearance between the extension J and the lift stop L and **must always be set after the sprayer spring compression has been set.** The lift should be set as follows:—

With the cap N removed and the locknut M slackened back, insert the 0·010 inch (0·25 mm.) gauge through the hole in the plug K and place between the extension J and lift stop L. Screw down the lift stop until it is just **touching** the gauge and tighten the locknut M. Never screw the lift stop L right down, as this would prevent the sprayer valve from lifting.

78. **SPRAYER SPRING COMPRESSION.**—When the sprayer leaves the works the spring compression is adjusted to give the correct blow-off pressure, and normally it will not be necessary to alter this setting.

(a) **Checking the Spring Compression.**—The blow-off pressure may be checked with a Test Pump. If the pressure is incorrect it should be reset as follows:—

(b) **Resetting the Spring Compression.**—With the cap N removed, the locknut S should be slackened and the lift stop L withdrawn, or at least slackened back. Remove the plug K and either add or remove a washer O. Removing a washer O gives more compression, adding a washer gives less compression. When attempting this operation only change one washer at a time.

After replacing the plug K the sprayer valve lift should be then set as described in paragraph 77, and the cap N replaced, making sure the locknut M is securely locked.

The sprayer can then be checked on the test pump again and further adjustments to the spring compression may be made if this is required. It should be noted that any alteration to the spring compression alters the sprayer lift and the latter should always be reset after washers O have been removed or added.

Paragraphs No. 79 to 81 apply to HH8 to HH14 and monobloc engines fitted with long spindle type sprayers.

79. **FUEL SPRAYERS.**—Fig. 47. It will be observed that the spindle D is located in the body C, whereas its seating is in nozzle B. It is **essential** that the nozzle seating is in correct alignment with the guide; this will be accomplished automatically by the self-centring properties of the sprayer, provided all parts are correctly assembled.

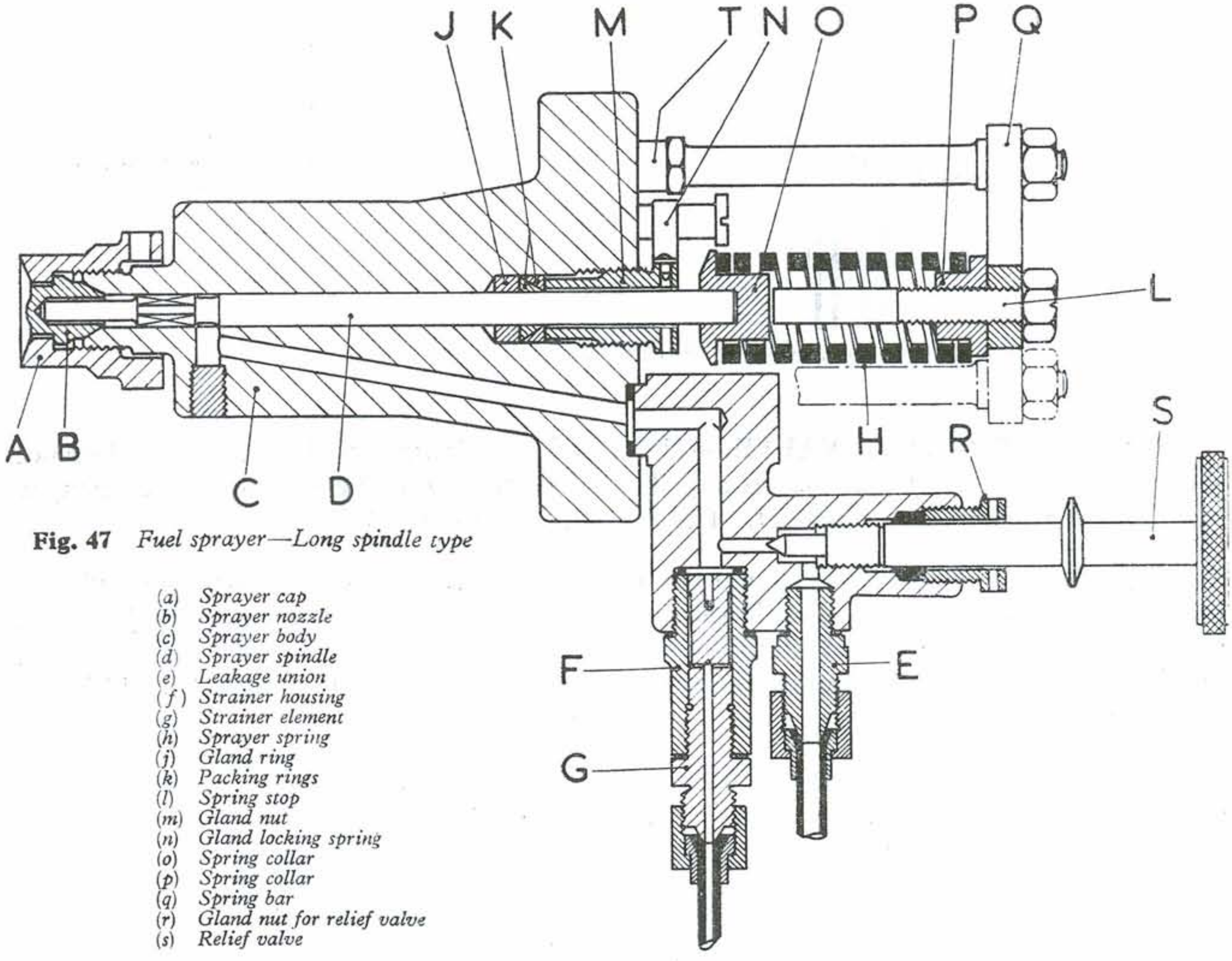


Fig. 47 *Fuel sprayer—Long spindle type*

(a) Sprayer cap
(b) Sprayer nozzle
(c) Sprayer body
(d) Sprayer spindle
(e) Leakage union
(f) Strainer housing
(g) Strainer element
(h) Sprayer spring
(j) Gland ring
(k) Packing rings
(l) Spring stop
(m) Gland nut
(n) Gland locking spring
(o) Spring collar
(p) Spring collar
(q) Spring bar
(r) Gland nut for relief valve
(s) Relief valve

80. **LIFT OF SPRAYER VALVE.**—To measure the lift of the spindle accurately, put the crossbar into position on the studs with the spring removed but the valve spindle in place. Take the plate gauge B, Fig. 45, supplied with the spares and insert the end between the end of the valve collar O, and the end of the stop L in the crossbar. Adjust and lock the stud **firmly** in the crossbar in such a position that the end of the plate gauge will just enter freely between them. It should be understood that this gauge is provided to record the previous conditions of the sprayer when the engine was tested. It is just possible that some slight modification to these gauge conditions may be advisable to suit local conditions, such as the quality of the fuel used, etc., but we do not usually recommend any change, and in any case any modifications should be very slight.

81. **SPRAYER SPRING COMPRESSION.**—The spring compression is permanently fixed at the works by the distance pieces T, so that no further adjustment is necessary.

82. **SPRAYER GLAND PACKINGS.**—Fig. 48. The packing of the sprayer gland must always receive careful attention, it consists of special rings.

After cleaning, or when re-packing, having removed the spring bar, first place the metal gland ring in position, and behind this one packing ring in the direction shown. **See that this is put in the right way up.** If it does not work very quickly the nut should be unscrewed a little, say, a quarter of a turn. **When the spring is removed it should be possible to move the spindle without difficulty when held between the thumb and forefinger.** When done, put the spring and crossbar in position, and tighten up the nuts.

There must **always be clearance between the gland nut and the spring washer,** otherwise the sprayer spindle will not be able to reach its seating and, in consequence, will not work satisfactorily. A locking device is added to prevent this gland nut slacking back.

When the engine is working, **the sprayer spindle should work very freely and very quickly, in fact so quickly that its motion can hardly be seen.**

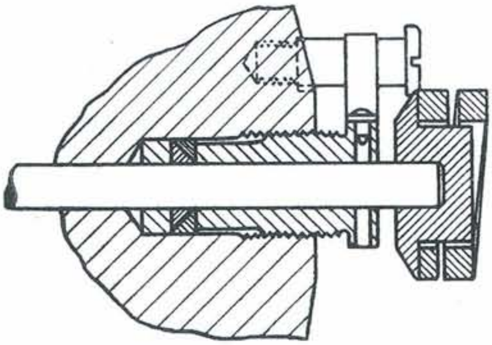


Fig. 48 *Glands for long spindle type sprayers*

Paragraph Nos. 83 to 85 apply to engines fitted with short spindle type sprayers

83. **FUEL SPRAYER.**—Fig. 49. It will be observed that the spindle D is located in the guide B. If this requires replacing it is recommended that the spindle should also be renewed.

(a) **Dismantling.**—When cleaning the sprayer it is not necessary to remove the spring stop K or the lift stop L; these should be locked in position. The spindle D, guide and nozzle should be removed after releasing the retaining cap A.

(b) **Re-assembly of Sprayer.**—Providing the setting for the spring stop K and lift stop L have not been altered, the sprayer parts may be cleaned and replaced, the cap A being tightened last of all.

When re-assembling the nozzle it is **important** to see that the nozzle is correctly lined-up with the sprayer body. The slot X on the body and Y on the nozzle should be approximately in line when the cap is tightened down. The complete sprayer is located in the breach end by the peg J.

The cap A should be tightened by the special spanner provided. A tube should **never** be used to increase the effective spanner length as this will result in over-tightening.

When the setting of the lift stop L and spring stop K has been disturbed, it is essential that the sprayer be erected as follows:—

The spring stop K **without** the lift stop L in position should be screwed into the body C before placing the body in a vice with the nozzle end uppermost. The spring H, stop Q, guide B and spindle D should then be placed in position, and the cap A tightly screwed down.

When the cap A is tightly screwed down, the spring stop K should be slackened back and the lift stop L inserted. The sprayer spring compression and sprayer valve lift should then be set as described in paragraphs 84 and 85.

The lift stop L must be removed as described, otherwise it may come into contact with the stop Q, and the tightening of the cap would force the spindle D through the nozzle.

84. **LIFT OF SPRAYER VALVE.**—Fig. 50.—The lift of the spindle D is limited to the clearance between the stop Q and the lift stop L and **must always be set after the sprayer spring compression has been set.** The lift should be set as follows:—

The locknut F should be slackened and the lift stop L screwed down **by the fingers only,** i.e. **clockwise**, until it is just touching the stop Q. The stop L should then be turned through one-third of a turn **counter-clockwise**. After setting, the stop should be locked by the locknut F, and the cap O replaced.

85. **SPRAYER SPRING COMPRESSION.**—Figs. 49 and 50.—When the sprayer leaves the works the spring compression is adjusted to give the correct sprayer blow-off pressure, and normally it will not be necessary to alter this setting.

(a) **Checking the spring compression.**—The blow-off pressure may be checked with a Test Pump. If the pressure is incorrect it should be reset as follows:

(b) **Resetting the spring compression.**—With the cap O removed, the locknut F should be slackened and the lift stop L withdrawn, or at least slackened back. The locknut R should then be slackened and the spring stop K unscrewed until it is slack following which it should be **carefully** screwed down clockwise, **by fingers alone** until it is **just** touching the sprayer spring H. The spring stop K should then be turned **clockwise** the required number of turns to give

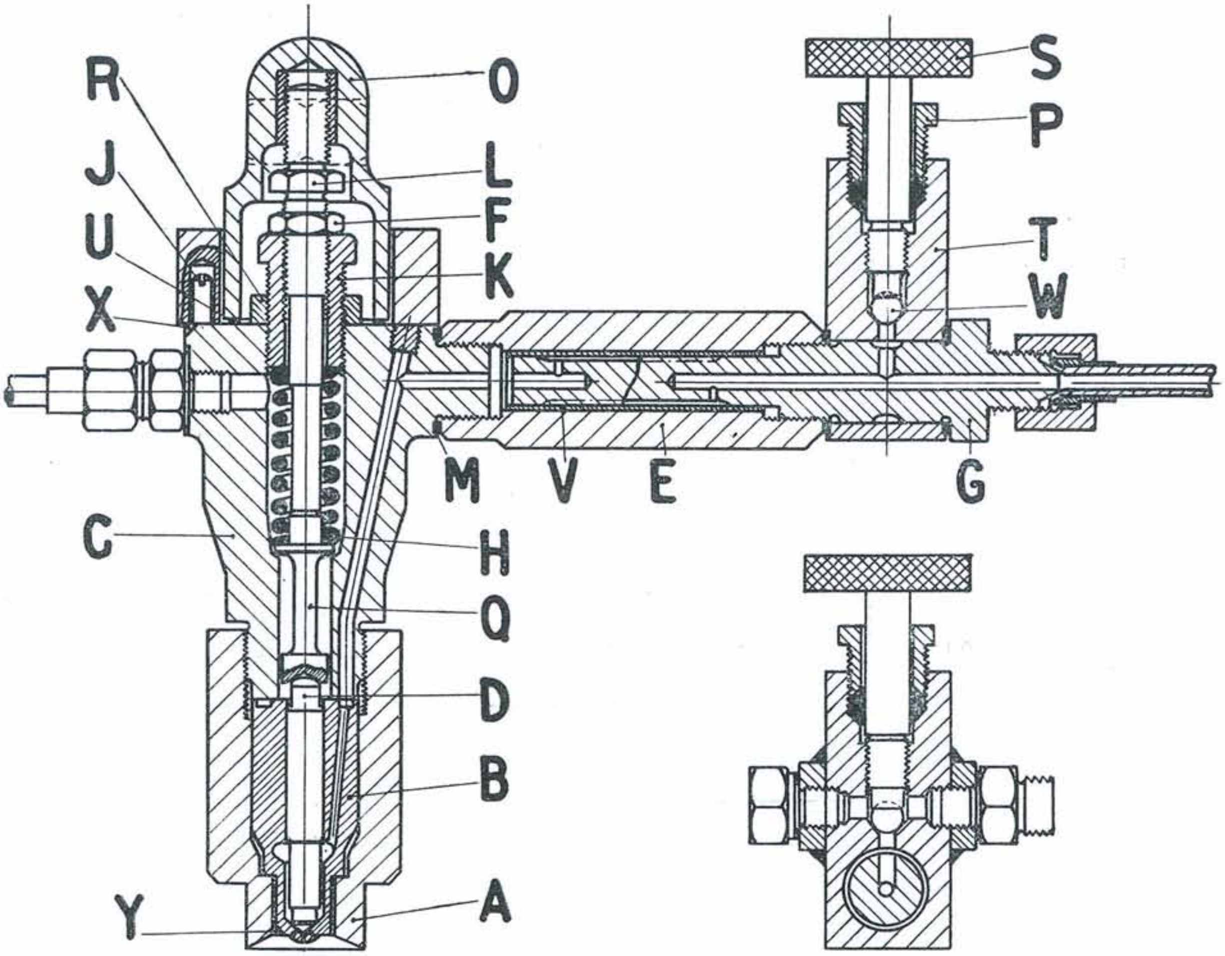


Fig. 49 *Fuel sprayer—Short spindle combined nozzle design*

(*a*)	*Retaining cap*
(*b*)	*Combined nozzle and guide*
(*c*)	*Sprayer body*
(*d*)	*Spindle*
(*e*)	*Strainer body*
(*f*)	*Locknut*
(*g*)	*Strainer*
(*h*)	*Spring*
(*j*)	*Locating peg*
(*k*)	*Spring stop*
(*l*)	*Lift stop*
(*m*)	*Washer*
(*o*)	*Cap*
(*p*)	*Gland nut*
(*q*)	*Stop*
(*r*)	*Locknut*
(*s*)	*Relief valve*
(*t*)	*Relief valve body*
(*u*)	*Washer*
(*v*)	*Bush*
(*w*)	*Ball valve*
(*x*)	*Slot in body*
(*y*)	*Slot in nozzle*

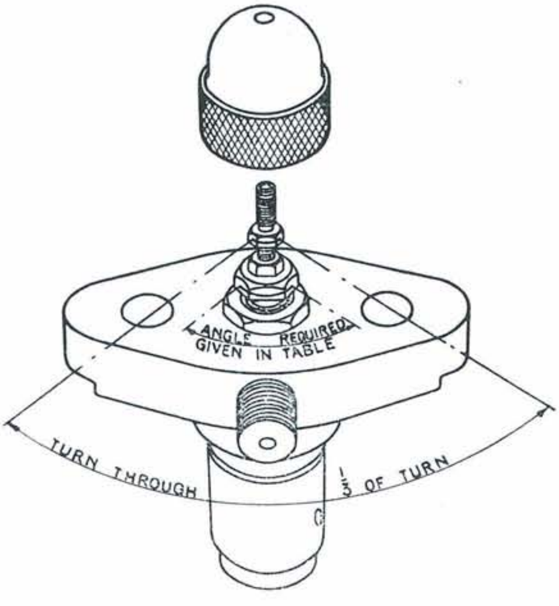

ANGLE REQUIRED GIVEN IN TABLE
TURN THROUGH $\frac{1}{3}$ OF TURN

Fig. 50 *Setting of sprayer and spring compression*

the correct blow-off pressure (see table) and then locked in position with the locknut R. The sprayer valve lift should then be set, as described in paragraph 84, and the cap O replaced.

The sprayer can then be checked on the test pump again and further small adjustments to the spring compression may be made if this is required. It should always be noted that any alteration to the spring compression alters the sprayer lift and the latter should always be reset after any such alteration.

If a test pump is not available, a reliable setting of the spring pressure will be obtained by the above method providing care is taken when giving the spring stop K the required number of turns.

Before replacing the cap O always make sure that the locknuts R and F are securely locked.

Engines	Sprayer blow-off pressure	Number of turns of spring stop K to give required blow-off pressure
All sizes	1600 p.s.i. (112 kg. per cm^2)	0·88

GOVERNORS

Note the type of governor fitted to the engine and then work to the appropriate paragraphs.

Paragraphs Nos. 86 to 88 apply to horizontal sideshaft design.

Paragraphs Nos. 89 to 92 apply to vertical pillar design.

86. **GOVERNOR—Horizontal sideshaft design.**—Figs 35 and 38. When the weights Y1 have reached their full speed position the governor gear is so set as to cause the control valve in the fuel pump to open at the correct instant, thereby cutting off the fuel supply to the cylinder. This is attained by the weights Y1, moving the governor sleeve Z1, along the sideshaft W1. The governor lever B2 which is secured to the sleeve operates the governor wedge Y1, so controlling the amount of fuel being delivered to the sprayer.

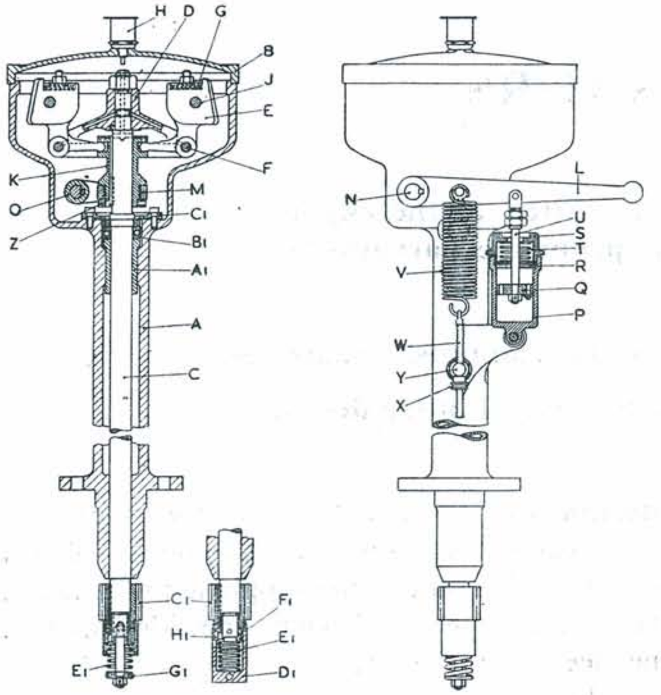
87. **GOVERNOR WEDGE.**—Figs. 35 and 38. When running at reduced load, the wedge will move horizontally until its thicker part is level with the pin C1, secured to the fuel pump lever. Thus the control valve will open early, and nearly all the fuel will pass back to the heater, a sufficient amount being delivered to keep the engine working at its correct speed.

88. **SPEEDER SPRING.**—Figs. 35 and 38. By adjusting the tension of the spring T1, on lever B2, the engine speed may be varied. No slackness must be allowed in the governor pins or gear as this would lead to irregular running. The speed must never be increased above that stated on the engine nameplate.

89. **GOVERNOR—Vertical pillar.**—Fig. 51. When the engine speed increases the weights E to move outwards, thus lifting the sleeve K and clip M, this motion being transmitted through the lever L to the gear operating the control valve in the fuel pump.

A dashpot P is provided to enable the movement of the lever to be damped. The dashpot spring T is to prevent the engine pulling up in the event of a sudden overload.

90. **GOVERNOR DASHPOT.**—Fig. 51. This must be kept full of lubricating oil of a quality similar to that used for bearing lubrication, and should be replenished every **2500 hours.**



(*a*)	*Governor box*
(*b*)	*Cover*
(*c*)	*Spindle*
(*d*)	*Governor weight carrier*
(*e*)	*Governor weight*
(*f*)	*Fulcrum pin*
(*g*)	*Washers*
(*h*)	*Lubricator*
(*j*)	*Spring pins*
(*k*)	*Sleeve*
(*l*)	*Lever*
(*m*)	*Clip*
(*n*)	*Fulcrum pin*
(*o*)	*Double lever*
(*p*)	*Dashpot body*
(*q*)	*Piston*
(*r*)	*Plate*
(*s*)	*Cover*
(*t*)	*Spring*
(*u*)	*Rod*
(*v*)	*Speed adjustment spring*
(*w*)	*Tension Rod*
(*x*)	*Speed adjustment nut*
(*y*)	*Speed adjustment pillar*
(*z*)	*Collar*
(*a1*)	*Spindle bush*
(*b1*)	*Ball thrust bearing*
(*c1*)	*Pinion*
(*d1*)	*Spring box*
(*e1*)	*Governor drive spring*
(*f1*)	*Locking nut*
(*g1*)	*Spring plate*
(*h1*)	*Locking screw*

Fig. 51 *Governor of the vertical pillar design*

To fill the dashpot unscrew the cover S and piston Q and partially fill the pot. Then replace the piston and press it down until it is submerged in the oil; this is necessary to prevent air being trapped beneath the piston. Then fill up to the top with oil and screw on the cover, when some of the oil will be forced out. As much oil as possible should be filled into the top of the cover to prevent air leaking in past the dashpot rod.

91. **SPEEDER SPRING.**—By adjusting the tension of the spring V on lever L the engine speed may be varied. Slackness in the governor pins or gear will lead to irregular running. The speed must never be increased above that stated on the engine nameplate.

92. **GOVERNOR WEDGE.**—Fig. 43. To prevent the engine reversing its motion, in case a greater load is thrown on the engine than it can carry, causing it to slow down considerably, the supply of fuel is arranged to be suddenly cut off. The nuts on the dashpot rod are set to compress the spring when the thinnest portion X of the wedge is in line with the control valve. The engine speed will then fall considerably before the fuel supply ceases, the latter only taking place when the speed has become slow enough to allow the thicker part of the wedge T to fall in line with the valve, the whole of the fuel then being returned through the control valve to the heater, thus acting as a safety device.

When running at reduced load, the wedge will rise until its thicker part Y rises level with the pecker bolt; thus the control valve will open earlier, and nearly all the fuel will pass back to the heater, a sufficient amount being delivered to keep the engine working at its correct speed.

BALANCING THE LOAD

DOUBLE CYLINDER AND MONOBLOC ENGINES

93. **THE REASON FOR BALANCE.**—When the engine is running on normal load each cylinder should carry an equal proportion of the load, which means that an equal proportion of fuel must be injected into each cylinder, and efficiently burned. The engine will be found to maintain an equal balance in a very stable manner. The recommendations in this section are a guide when a complete resetting is necessary.

94. **EXHAUST TEMPERATURES.**—The approximate load carried by each cylinder can be determined by thermometers fitted into the exhaust bends. When an equal amount of fuel is injected into each cylinder **and the sprayer, pump, etc., are in an efficient condition,** then the temperatures should be balanced.

Method of ascertaining Balance.—An engine may be said to be out of balance when any of the exhaust temperatures are 25°F. (14°C.) above or below the average reading of the thermometers with the engine running at its rated load. Should the variation exceed this limit an inspection should be made to ascertain the cause of trouble. A certain amount of unbalance at light loads is no cause for concern, provided that the engine is in balance at the rated load.

Thermometers should be checked periodically for both accuracy and cleanliness also the pockets for freedom from carbon.

95. **REASONS FOR UNBALANCE.**—

(a) **Unsatisfactory Mechanical Condition.**—Due to unsatisfactory fuel sprayer; faulty fuel pump. Erratic fluctuations in temperature of any cylinder denotes a mechanically unsatisfactory sprayer or pump.

(b) **Unequal Fuel Charge.**—Due to too large or too small an amount of fuel charge as determined by the pump pecker clearance—

If the original pecker clearances have not been interfered with, any alteration required will be due to wear. As wear is only slight, it will be understood that adjustment of the pecker clearance is only a very occasional operation. Do not tamper unnecessarily with the pump adjustment.

96. **PROCEDURE FOR RE-BALANCING.**—It is important that the mechanical condition of the engine is satisfactory before adjusting the pecker or governor wedge clearances. Obviously it would be a mistake to alter the amount of fuel injected when the cause of unbalance is a choked sprayer nozzle, or an unsatisfactory pump. Therefore the operator should proceed systematically to locate the cause of unbalance by first examining the sprayer for cleanliness, ascertain if the sprayer spindle is sticking, check the lift of the spindle, see that the nozzle holes are clear, and examine the condition of the sprayer valve seating.

Make sure the fuel pump plungers and control spindles are not sticking and no springs are broken. The fuel pump should next be tested for being "solid." Attention should also be paid to the fuel pump delivery valves, as a faulty delivery valve will cause the exhaust temperature of the corresponding cylinder to drop. It is therefore important that all delivery valves should be tested, before the cylinders are re-balanced by adjusting the pecker clearance on monobloc engines and the governor wedge clearance on double cylinder engines.

Should it be found after careful investigation that the sprayer and fuel pump are correct and the temperature of the cylinder is still out of balance, then it can be concluded the amount of fuel injected is either too great or too small, according to whether the temperature of the defective cylinder is too high or too low.

When adjustments to the amount of fuel injected are made, the following precautions are necessary when making an adjustment:—

Monobloc Engines

(a) Run the engine on normal load until it is thoroughly warm, to allow the exhaust temperatures to settle.

(b) When making an adjustment do not exceed an eighth of a turn of the screw C, Fig. 44, at each adjustment, and allow a quarter of an hour after each adjustment to enable the temperatures to settle once more.

(c) Ascertain that the locknut is tightly locked after each adjustment.

(d) If the adjustment has made the pecker clearance abnormally different from the original setting, then the cause of the unbalance was not due to incorrect pecker clearance but to unsatisfactory mechanical condition of the engine. The real fault must be remedied and the pecker clearance brought back to normal.

Double Cylinder Engines

(a) Run the engine on normal load until it is thoroughly warm, to allow the exhaust temperatures to settle.

(b) Adjustment may be made by altering the clearance between the pecker and wedge. It is important that the governor rods must be of the exact length to bring the point X Fig. 43 on the wedge opposite the control valves when the governor weights are nearly at their innermost position. If correctly set, the parallel parts at the bottom of the wedges will be opposite the control valves when the weights are at their outermost position.

(c) Ascertain that the locknuts for the governor rod are tightly locked after each adjustment.

(d) If the cause of unbalance was not due to incorrect governor wedge clearance but to unsatisfactory mechanical condition of the engine, then the real fault must be remedied and the governor wedge clearances brought back to normal.

ENGINE CYLINDER

97. **AIR SILENCER.**—This consists of a central body surrounded by matting or a brass gauze and enclosed by a cover. The matting or gauze should be cleaned every **200 hours,** and if the atmosphere is dusty the cleaning should be more frequent. Do not add to the quantity of matting or gauze in the silencer.

Great care should be taken that the air supply is not drawn from a heated or impure source, which will reduce the power developed.

The brass gauze can be cleaned in paraffin or clean fuel.

Matting in a choked or bad condition should be replaced.

Where an air filter is used it must be sufficiently large and must not restrict the free flow of air.

98. **BREECH END.**—The efficiency of the engine depends on the cleanliness, both in the combustion chamber and the surrounding water jackets. The breech end contains:—

(a) **Combustion chamber.** — This should be examined by removing the air valve block and breech end every **2,500 hours,** but more often if viscous or dirty fuels are used. Particular care should be taken to remove carbon which may have become deposited around the hole through which the sprayer nozzle protrudes, and from the space between the breech end and back of the piston.

(b) **Fuel sprayer** is centrally located, and described in paragraphs 67 to 85.

(c) **Automatic air starter valve, when fitted.**—This unit is described in paragraphs 119 to 120, and should be taken out for inspection every **1,250 hours** and the valve ground in if necessary. After cleaning the valve should be smeared with lubricating oil before replacing. The joint washer seating should be kept in good condition.

(d) **Ignition tube, when fitted.**—When starting by means of a blow lamp, it may be found that the tube has become blocked up with carbon, thus making starting difficult. The tube must be taken out and cleaned.

(e) **Air and exhaust valves.**—These should be examined every **650 to 700 hours,** and, if necessary, ground in on their seatings. Care should be given to the grinding-in of the exhaust valve, since if the engine operates with a valve which is leaking, the heat and speed of the escaping gases will soon eat the metal away.

Fill the air valve lubricator A Fig 52. **daily,** also the exhaust valve lubricator on the smaller engines.

(f) **Water jackets.**—Where the water is "hard" or contains much lime, chalk, mud or vegetable matter, examine the water spaces frequently and remove any scale or deposit; inspection covers are provided for this purpose.

When joint between liner and breech end is of asbestos smear both sides with boiled linseed oil.

99. **REMOVING AND REPLACING THE BREECH END.**—Before removing the breech end the water in the jackets must be drained. The breech end, when removed, should be stood on wood; not on hard material. Care must be taken not to damage the spigot.

The water connections, fuel sprayer, and air starting pipes should be taken off, also the exhaust pipe should be disconnected. When the breech end stud nuts are removed the breech end can be removed horizontally.

Before replacing the breech end, remove any carbon deposits on the piston crown, and combustion chamber.

Observe great cleanliness when replacing the breech end and ensure that all joints are in place.

100. **BREECH END STUDS.**—The nuts of these studs must be tightly screwed up from time to time especially when the engine is first started. On larger sizes, access to two of them is only possible when the air valve block is removed ; a special spanner is provided.

101. **BREECH END CLEARANCES.**—Whenever it is necessary to withdraw a piston, adjust a connecting rod large-end bearing, or remove the breech end, it is advisable to re-check the breech end clearance **before and after** doing so. This will immediately confirm that everything has been replaced correctly and ensures that the pressure will be correct.

The clearance between the breech end and piston can be checked by first removing the air valve body. A length of lead wire, 0.125 inch (3.0 mm.) diameter, should be taken and the end bent round forming an "L" at the end, the bent portion being doubled and about 1 inch (25.0 mm.) in length. The lead wire should be then inserted, keeping the wire as far away from the centre of the cylinder as possible, i.e., the tail lying against the wall of the cylinder. The crankshaft should then be barred round until the piston crown has trapped the lead wire.

Upon removing the lead wire it will be found that the end has been flattened so that it can be measured with a micrometer—see technical data. The clearance before and after a piston or breech end has been removed should always be the same.

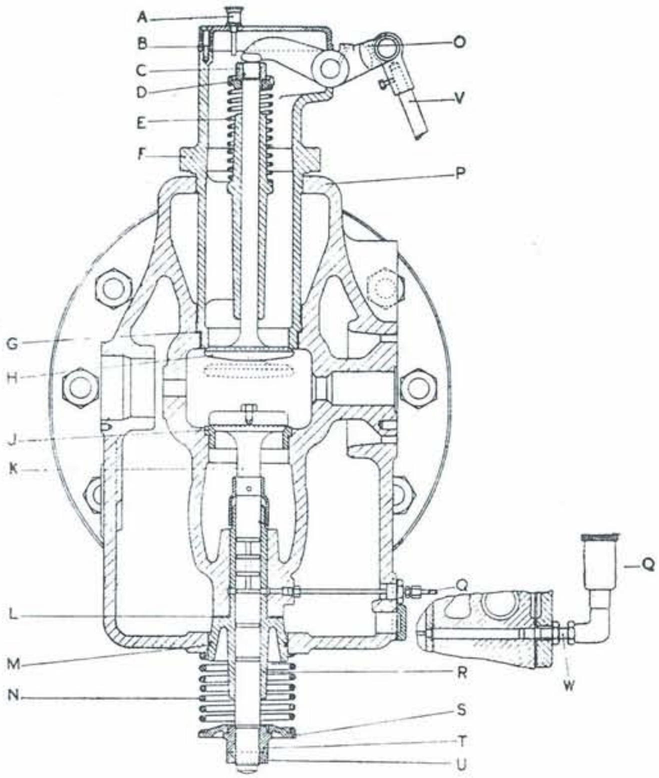
In the event of the wire not being flattened, it should be bent so there are three thicknesses of lead on the bent portion. The clearance should be again measured.

To decrease or increase the clearance adjust the thickness of the packing plates between the connecting rod and the large-end bearing.

After adjusting the compression pressure, the alignment of the piston and connecting rod assembly should be carefully re-checked.

The final adjustment should only be made after using an indicator.

102. **CYLINDER LINER.**—Fig. 28.—The cylinder liner is renewable and an inspection each **2,000 hours** is usually sufficient. Replacement is not necessary until wear has taken place up to approximately the limits given in the maximum wear tables. A guide is that the liners will not need renewing until the wear is such that starting is difficult, piston rings stuck, and when carbon build-up becomes too frequent. Some falling off in power is to be expected in the later stages before renewal.



(*a*)	*Lubricator for air valve*
(*b*)	*Cover for air valve block*
(*c*)	*Head for air valve spindle*
(*d*)	*Collar for air valve spindle*
(*e*)	*Air valve spring*
(*f*)	*Air valve block*
(*g*)	*Joint for air valve block*
(*h*)	*Air valve*
(*j*)	*Seating for exhaust valve—when fitted*
(*k*)	*Exhaust valve*
(*l*)	*Joint for guide—when fitted*
(*m*)	*Joint ring for guide—when fitted*
(*n*)	*Exhaust valve spring*
(*o*)	*Air valve lever*
(*p*)	*Breech end*
(*q*)	*Exhaust valve lubricator or pipe*
(*r*)	*Exhaust valve guide*
(*s*)	*Spring plate—when fitted*
(*t*)	*Nut for exhaust valve*
(*u*)	*Locknut for exhaust valve*
(*v*)	*Air valve rod*
(*w*)	*Exhaust valve lubricator connection*

Fig. 52 *Representative section through the breech end as used on horizontal engines*

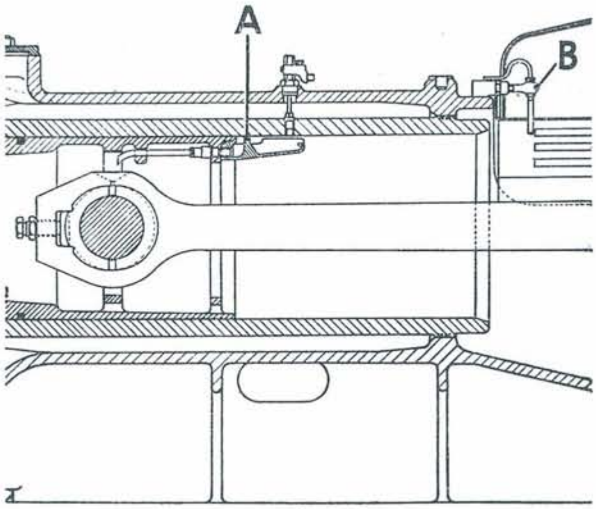


Fig. 53 *Arrangement of oil boat for piston*

(A) *Oil trough*

(B) *Adjusting bar*

103. **PISTON.**—Fig. 28.—These are either of the slipper design with fixed piston pin or the trunk design with fixed or floating piston pin. Lubricating oil for the piston pin runs down to a wick in front of the cylinder. The bottom of the wick should be clear of the projection in the oil trough A shown in Fig. 53 by a clearance of 0.002 to 0.005 inch (0.05 to 0.12 mm.) when the piston reaches the end of its outstroke. The oil is thus transferred to the trough A attached to the piston from whence it passes down the connecting rod small-end bearing. On the smaller engines the oil is collected from the cylinder liner and is led to the connecting rod small-end bush through an oil tube in the piston, see Fig 28.

Sufficient oil must be used to keep the whole piston surface well lubricated. Excessive oil may get to the back of the piston, but when too little oil is used the piston will become dry in places and may tend to create seizure The piston should not be removed except for cleaning or to replace a ring.

Inspection after approximately each **2,000 hours** is usually sufficient, but the period between cleaning is best determined by experience on each installation; when the cylinder liner is worn inspection should be more frequent.

The piston crown can be cleaned when removing the breech end and without removing the piston from the cylinder. Piston crowns should be examined for possible cracks due to overheating and should be renewed before there is any possibility of cracks developing to such an extent as to penetrate through the metal.

It is not necessary to remove carbon from the surface of the piston between the rings. Do not remove rings if they are free in their grooves.

When a cylinder is worn enough to form a step in the bore, the carbon should be removed from the grooves underneath the rings in order to make removal easier.

When replacing thoroughly lubricate the piston and liner. See that the pegs fit into the ring gaps correctly, and the correct gap clearance is used.

In the event of a repeated drying piston condition developing first make sure that the exhaust system has been correctly installed.

When in the normal course of service wear occurs in the piston bosses of the floating pins then the piston can be reconditioned by the introduction of bronze bushes.

Piston and connecting rod alignment. New pistons should be withdrawn after four or five hours' run in order to check that the alignment is correct. A similar procedure should be carried out after fitting new connecting rod bearings. The alignment may be rectified if faulty by very carefully throwing the connecting rod from the palm end. Thus, if the piston is brightly marked on the left-hand side of the junk and the right-hand side at the bottom of the skirt, the right-hand side of the palm end of the connecting rod should be very slightly eased to throw the piston into line. Such work should only be carried out by an expert and it is of the utmost importance that the palm end of the connecting rod should only be eased as a maximum 0.001 inch (0.025 mm.), the filing should be tapered from 0.001 inch (0.025 mm.) maximum on the right-hand side, to nothing on the left-hand side, or vice versa, according to the direction in which the piston requires throwing. The filing must be kept absolutely flat and should be checked with a surface plate.

104. **PISTON RINGS.**—The rings should be free in the grooves. The top piston ring may get gummy in its groove but **if it is bright all the way round, then it is in a working condition. A ring which is definitely stuck, and not working, is black on its surface.** Broken rings must be replaced. Never run with a broken piston ring and replace badly worn rings one at a time.

Replace the top two pressure rings of each piston after one year, then the bottom two pressure rings after a further period of twelve months. Thereafter, repeat this process only when the wear of the piston rings justifies it.

All the piston rings should have an axial clearance between ring and groove and this clearance varies with the type of ring.

When wear on the plain full and half width rings, also oil scraper rings, occurs the clearance should not be permitted to increase beyond the limits in the technical data.

The gap clearance on the plain and oil scraper rings as given in the technical data section should be regarded as a maximum figure.

The butt clearance should be measured with the piston ring placed in an unworn portion of the liner, i.e., at the crankshaft end. The ring should be square with the axis of the cylinder.

All pegs must be quite clear when the rings are pressed into contact on their butt ends. Binding must not occur. Replace any piston ring pegs which may be missing.

Piston Ring Arrangement.

(a) **HD4 to HH6 and IHD4 to IHH6 engines.**—Plain full width rings in all grooves.

(b) **HH7 to HH10 and IHH7 to IHH10 engines.**—Plain half width ring in top groove, with a plain full width ring in the second, third and fourth grooves.

(c) **HH11 to HH14 and IHH11 to IHH14 double cylinder and monobloc engines.**—Plain full width ring in top groove, double seal ring in second groove, third groove no ring, and fourth groove plain half width ring.

105. **PISTONS IN A NEW ENGINE.**—The useful life of an engine is dependent on the care it receives during its early life. During this period the various bearing surfaces become bedded down and it is of the utmost importance that the piston developes a smooth bedding surface and the cylinder a glassy smooth finish.

Prolonged overloading of the engine may result in slight growth of the piston above the gudgeon pin, with a consequent reduction in working clearance, and if this occurs score marks may appear on the piston and possibly on the cylinder liner surface. Failure of the circulating water, or of the lubricating oil supply to the piston unless observed in time, may also result in scoring or seizure of the piston and liner.

Should the attendant observe the engine to falter, slow down, or even stop altogether through temporary seizure, the matter should receive immediate attention. Having first made sure that the symptons are not due to some obvious cause such as lack of fuel, or air lock in the fuel system, the attendant should remove the piston. Should score marks be found on the piston or, alternatively, hard bright spots, then these should be well eased, finishing off with a dead smooth file and polishing with emery cloth. When score marks are very hard remove the skin with a carborundum stone.

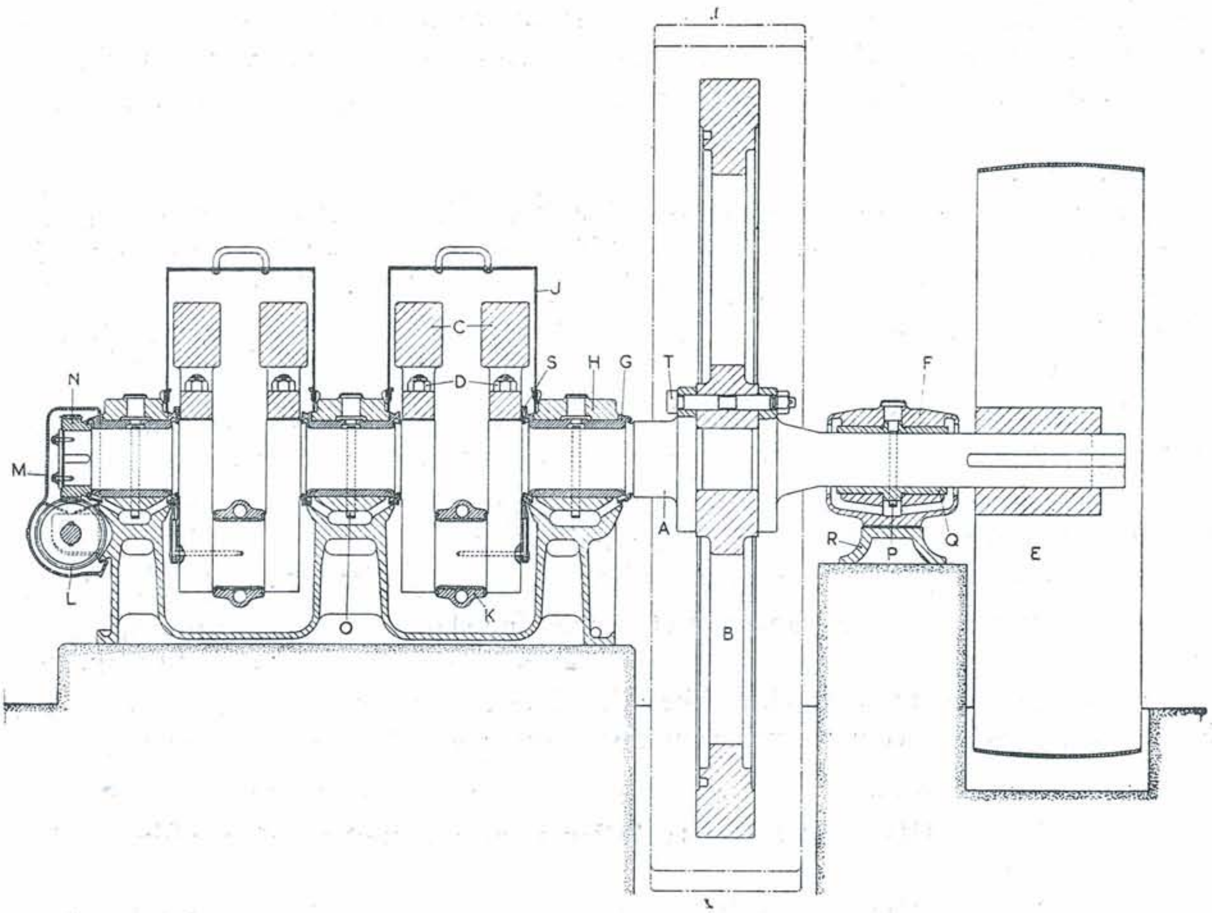


Fig. 54 *Crankshaft and main bearings for double cylinder monobloc engines*

(*a*) *Crankshaft*
(*b*) *Flywheel—flanged mounted*
(*c*) *Balance weights*
(*d*) *Balance weight studs and nuts*
(*e*) *Pulley*
(*f*) *Outend bearing body*
(*g*) *Main bearings*
(*h*) *Main bearing caps*
(*j*) *Splasher guard*
(*k*) *Connecting rod large-end bearings*
(*l*) *Sideshaft gearwheel*
(*m*) *Guard*
(*n*) *Crankshaft gearwheel*
(*o*) *Oiling rings for main bearings*
(*p*) *Oiling rings for outend bearing*
(*q*) *Outend bearing*
(*r*) *Outend bearing soleplate*
(*s*) *Ring lubricator*
(*t*) *Flywheel coupling bolts*

The amount of metal that should be removed in the event of seizure, either in taking out score marks or hard bright spots, should progressively diminish as one travels towards the open end of the piston.

The junk of the piston, i.e., that part of the piston above the top ring, should be eased should hard bearing marks appear.

The piston skirt should be eased only in the event of seizure or scoring, it may be necessary to replace some of the piston rings.

Except in cases of severe seizure the liner will be only slightly marked. These marks usually take the form of a hard scab, which consists of a very small quantity of metal deposited on the cylinder wall as a result of local melting of the piston during the intense heat generated. It is of the utmost importance that it be completely removed with a carborundum stone, no matter how long this may take; if it is not removed completely seizure may recur.

During the first few days of running the load should be gradually applied.

The piston should be removed for inspection at the end of the first **1,250 hours,** and if the bearing surfaces are satisfactory the piston may be considered to be completely bedded in.

106. **CRANKSHAFT MAIN AND OUTEND BEARINGS.**—Each half of the crankshaft bearing must fit metal to metal after tightening down the bearing cap nuts, the requisite clearance being obtained by scraping the inside of the bearings just sufficiently to allow the engines to run without "knock" or heating up. On no account is the clearance to be obtained by adjusting the nuts. The filing and bedding down of bearing brasses should only be entrusted to a skilled mechanic.

The crankshaft alignment should be checked with dial micrometer every **2,500 hours.**

These bearings are lubricated by oiling rings which dip into lubricating oil wells. Sight gauges show the level of oil in the wells, which should be clearly visible at the top of the gauge when the engine is at rest.

Should any bearings show signs of overheating the most likely cause is that the quantity of oil is deficient or the quality unsuitable.

Examine the oiling rings to see that they are clean and rotating properly. Should dirt or water accumulate in the wells or lubricators, or if the oil is of an inferior quality, there may be a tendency for a gummy substance to form and adhere to the oiling ring, thus preventing oil being distributed over the bearings.

The oil wells should be thoroughly cleaned out and replenished with fresh oil every **2,500 hours.**

When the cause of overheating is not ascertained quickly, **the engine should be stopped** to avoid any serious damage. Should any bearing, after having been overheated, be found difficult to run cool again, it can be lubricated with castor oil for some hours.

Heating of the main and outend bearings may be an indication of the bearing **being out of line,** through incorrect alignment, or subsidence of the foundation. This must have immediate attention and be remedied by a skilled erector.

107. **BEARING METALS (a) Connecting Rod Large-end Bearing.**—On some engines a bronze bearing is used, and on other engines the bearing consists of a housing lined with a high grade whitemetal. When re-lining is necessary a whitemetal having a tin content of not less than 90 per cent is recommended and one not inferior to Hoyts "11R" grade should be used.

(b) **Crankshaft Main and Outer Bearings.**—Bronze or whitemetal bearings are used according to the engine size. When whitemetal bearings need re-lining a whitemetal having a tin content of not less than 89 per cent should be used and one not inferior to Hoyts "11D" grade.

(c) **Connecting Rod Small-end Bearings.**—These are of bronze, and should be adjusted or replaced according to design.

108. **CONNECTING ROD BEARINGS. Large-end.**—Oil is fed from the mechanical lubricator into the ring lubricator attached to the crankshaft. The ring lubricator pipes and the oil holes must be kept clean. Make certain that the oil pipe feeds into the ring lubricator and there is no oil leakage between the crankshaft and ring lubricator.

A cup is provided on the bearing to prime the bearing with oil before starting. Any metallic 'knock' must be cured as it becomes apparent, by re-adjustment of the running clearance.

No engine should be allowed to run with a perceptible knock in the bearing as a severe strain is put upon the bolts and may cause breakage. **This is a most important matter and must on no account be neglected.** The breaking of a connecting rod bolt may lead to a serious accident.

It is important to remember that when the clearance in the bearings is being reduced the requisite clearance must be left between the pin and the bearing, but **NO** clearance must be left between the two half bearings, and the nuts must be tightly screwed up, locked, and fixed by the locking screw. Excessive clearance will cause cracking of whitemetal linings. **On no account is the clearance to be obtained by adjusting the nuts of the bolts.** A pin is sometimes placed behind the nut on the bolts, and as the adjustment is taken up one or more thin washers must be placed between the face of the nuts and the pin.

Small-end.—When this bearing is in halves it must be adjusted as required to give the correct running clearance; The clearance must be between the piston pin and bearing when the adjusting screw is screwed tightly up to the bearing and securely locked with the locknut.

Where a solid bush is used with the floating type of piston pin it must be replaced when the maximum wear limit has been attained.

109. **CONNECTING ROD BOLTS.**—Fig. 55. Insurance companies advise their clients to replace the bolts with new ones after **15,000 hours'** running. This is to prevent any possibility of breakage, in case at any time they may have been working in a loose condition, or with a piston that may have seized in the liner, due possibly to lack of oil or excessively hot water in the jacket. **This renewal of bolts is a very wise precaution.** Furthermore, the bolts may have become twisted or lengthened due to injudicious tightening up. The bolts must be tightened up equally. Accidents have been known to occur because of one bolt being loosely adjusted, the other taking the greater part of the strain. Keep the bolts polished and a crack can then be seen at its early stage.

Examine the bolts carefully from time to time to see if any flaw can be detected. We mark each bolt with a line running along the whole length. Place a straight edge or steel rule along this line and examine very carefully to see that no twist has taken place; a more accurate method is to place the bolt in vee-blocks and try the line with a scribing block. A centre-punch mark has been made on the bolt and the table gives the dimension "A". This must be measured carefully on each occasion the rod is dismantled and the length checked to see that no undue elongation has taken place. We give the maximum permissible twist and elongation for each bolt. **When either or both of these has been reached the bolts must be rejected and new ones fitted.**

IMPORTANT.—Connecting rod bolts **must not be annealed,** as they are made from a special steel and undergo a special form of heat treatment. **Therefore when replacing the bolts with new ones be sure to order them from us so as to be absolutely sure of both the special material and the special heat treatment being properly carried out.**

Should a piston seize in the liner a great strain is thrown on the bolts and consequently the engine should never be run after such a seizure until new rod bolts have been fitted, since the old bolts will be sure to have been over-strained.

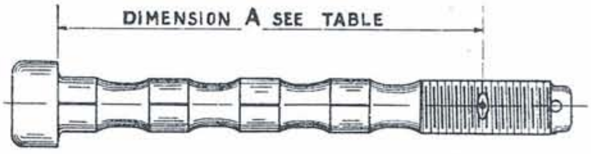


Fig. 55 *Connecting rod bolt*

Size of Engine	Dimension "A"		Maximum Extension		Maximum Twist	
	ins.	m/m	ins.	m/m	ins.	m/m
HD and IHD4	6	*152.4*	0.016	*0.4*	0.063	*1.5*
HD, HH, IHD and IHH6	7	*177.8*	0.016	*0.4*	0.063	*1.5*
HD, HH and IHH7	7	*177.8*	0.016	*0.4*	0.063	*1.5*
HD, HH and IHH8	7.5	*190*	0.016	*0.4*	0.063	*1.5*
HD, HH and IHH9	8	*203*	0.016	*0.4*	0.063	*1.5*
HD, HH and IHH10	9	*228*	0.017	*0.43*	0.063	*1.5*
HD, HH, IHH, 2HH and 2IHH11	11	*279*	0.020	*0.51*	0.063	*1.5*
HD, HH, IHH, 2HH and 2IHH12	11	*279*	0.020	*0.51*	0.09	*2.4*
HD, HH, IHH, 2HH and 2IHH14	13	*330*	0.024	*0.61*	0.13	*3*

110. **VALVE TIMINGS. Air and Exhaust Valves.**—The approximate positions of the crankshaft at which the valves open and close, that is when the rollers and cams are just making contact, are given in paragraph 19. These positions are ascertained by turning the crankshaft until it is **just** possible to revolve the roller on the cam.

111. **KNOCKING.**—A "knock" is generally attributed to wear in moving parts or excessive running clearances, and is especially pronounced when occurring in the reciprocating masses.

A heavy thud may sometimes be heard immediately after injection has taken place, thus indicating too early ignition—in this case it is necessary to retard the timing of the fuel pump cam, see paragraph 54. Care is exercised to obtained the most advantageous timing at the works, and it is seldom necessary to make any alteration provided a good quality of fuel is used. Other causes of knock are as follows:—

(a) Backlash in the sideshaft wheel teeth. A setscrew is provided underneath the sideshaft bearing to raise the bearing, and so set up the wheel further in gear.

(b) Too much running clearance in the connecting rod large-end bearing, or in the main bearing on the sideshaft side; or if the cap has not been properly tightened down, will permit the crankshaft to lift when the power impulse takes place; or loose connecting rod small-end bearing liners.

(c) When the outer bearing is lower there will be a tendency for the shaft to lift on the sideshaft side.

(d) Loosely fitting flywheel keys **must be tightened up immediately.** On no account must packings be inserted. New keys must be made if the existing ones cannot be made a good fit on their tops and sides. Serious accidents have occurred through slack keys setting up severe stresses which have resulted in the fracture of the boss of the flywheel.

(e) Badly fitting pistons or piston rings.

(f) Broken piston rings, remove at once and replace.

(g) Wear having taken place upon the internal surface of the liner and a ridge formed. When new connecting rod bearings are fitted, if the correct distance between the centres of the piston pin and crankpin bearing is not maintained, the piston may travel further into the cylinder, and so cause the first ring to strike against this ridge. This obstruction should be filed away.

(h) Very severe stresses may also be set up in the connecting rod bolts, owing to excessive knock due to a worn crankpin bearing.

(i) A knock may be traced to too much clearance between the exhaust valve and the tappet in the lever.

112. **GEARWHEELS.**—Although a label is attached to the gearwheels directing mechanics to gear up the wheels to the marks "o" on the teeth, we again call attention to this point as mistakes are often made in putting these wheels together. We also paint the tooth on one wheel and adjacent teeth space on the other red, in order to further call attention to this subject.

When erecting double cylinder engines it is necessary to **replace the sideshaft wheels in gear with the crankshaft wheels, so that the valve timings are precisely the same as fixed during the engine test.** To ensure this, proceed as follows :—

(a) Put the sideshaft wheel of one cylinder into gear with the wheel on the crankshaft so the marks "o" stamped on the wheels coincide.

(b) Turn the flywheel round through one revolution and then see that marks "o" stamped on the crankshaft wheel and the sideshaft wheel of the second cylinder coincide in the same way. An ignition will then take place at each revolution of the crankshaft, first in one cylinder and then in the other.

Two keyways are cut in the sideshaft gearwheel. If considerable wear of the teeth takes place, the wheel may be keyed on in a position diametrically opposite to its original one. If the attendant should effect this change the marks on the stamped painted teeth should be changed to suit. The valve settings, given in technical data, should then be carefully checked over, to see that they agree with the diagram, Fig. 27. Particular care should be taken to see that the sideshaft wheel is well up to the sideshaft bracket so that the valve settings may be correct. To reduce wear and ensure quiet running a mixture of oil and graphite may be used in the oil bath in the proportion of about 10 parts of oil to one of graphite. Care must be taken to see that the graphite does not choke the oil grooves and hole in the sideshaft bracket.

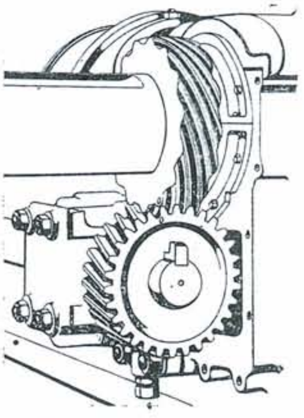


Fig. 56 *Position of markings on sideshaft and crankshaft gearwheels*

113. **FLYWHEELS.**—For mounting or dismounting the flywheels:—

(a) **Solid Flywheels.**—The bore is accurately machined to gauge, to obtain a tight fit on the crankshaft. **Do not file the shaft or scrape the flywheel bore** to make an easy fit, as this can cause the flywheel to run out of true.

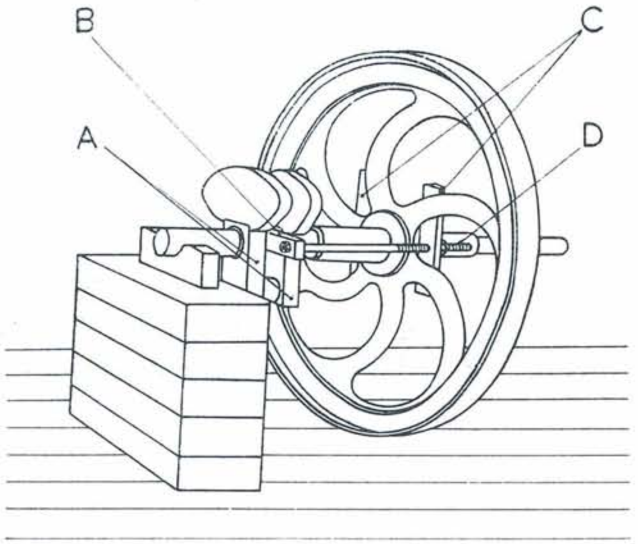


Fig. 57 *Withdrawing tackle for solid flywheels*

(a) Crankshaft webs
(b) Horizontally positioned plates
(c) Vertically positioned plates
(d) Bolts

Fig. 57 illustrates the method of drawing the flywheel on to the crankshaft. The flywheel is placed upright on the floor, or if preferred, is suspended by a sling from a crane or pulley blocks. The crankshaft is then lifted into position and passed as far through the flywheel boss as is possible. The short end of the crankshaft is then placed on a support and vee block. Place a plate B between the crankshaft webs, pass the bolts D through holes in the plate and the flywheel arms, and place another plate C across the arms. Screw on the nuts and proceed to tighten up, putting an equal pressure on both bolts, until the flywheel is correctly positioned. Then drive the keys in tightly.

To withdraw the flywheel proceed as previously described except that after withdrawing the flywheel keys, the bar B must be placed on the end of the crankshaft and the plates C on the opposite side of the flywheel arms.

(b) **Solid Wheels with Split Bosses.**—Before passing the crankshaft into the flywheel bore it is necessary to unscrew the flywheel boss bolt nuts and drive iron wedges between the halves of the boss. This permits the flywheel to be placed into the position on the crankshaft without difficulty.

Instructions for Assembling the Split-boss type Flywheel.—When opening the split boss with the steel wedges, it is possible to slightly displace the two halves relative to each other.

After removing the wedges, and before tightening the boss bolts, and driving in the keys, the erector should place a straight edge across the face of the boss, and test with feelers. If it is found to be slightly 'stepped', a smart blow on the half displaced will be sufficient to restore the boss to its original position, failure to carry out this simple check may result in a "wobbling" flywheel.

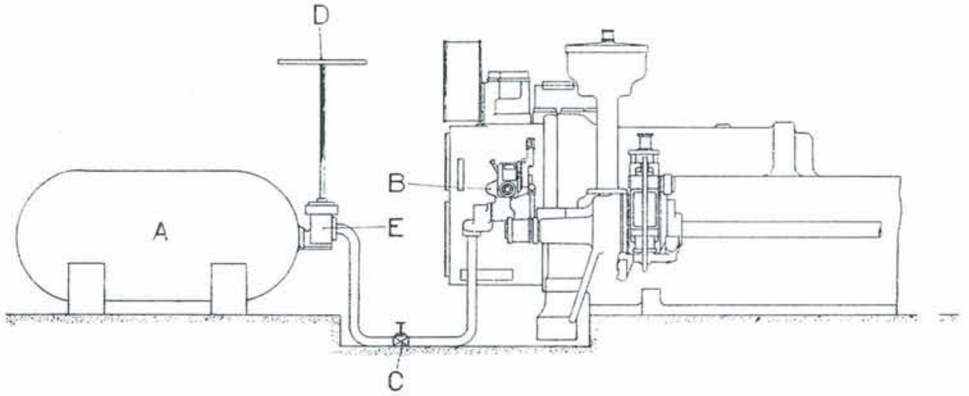
The boss bolts should be finally tightened before driving in the keys.

(c) **Split Flywheels.**—Before assembling, the joints of the rims should be cleaned with a wire brush, to ensure that the halves meet together metal to metal at the rim.

One half of the flywheel should then be lifted into the flywheel pit, being packed up to the correct height to suit the level of the crankshaft, which latter should then be lifted and carefully lowered into its bearings. The dowels should be placed in the holes in the lower half of the flywheel, particular care being taken to observe the number stamped on them, a corresponding number also being stamped on the large-end of each cotter and against each cotter hole in the flywheel rim.

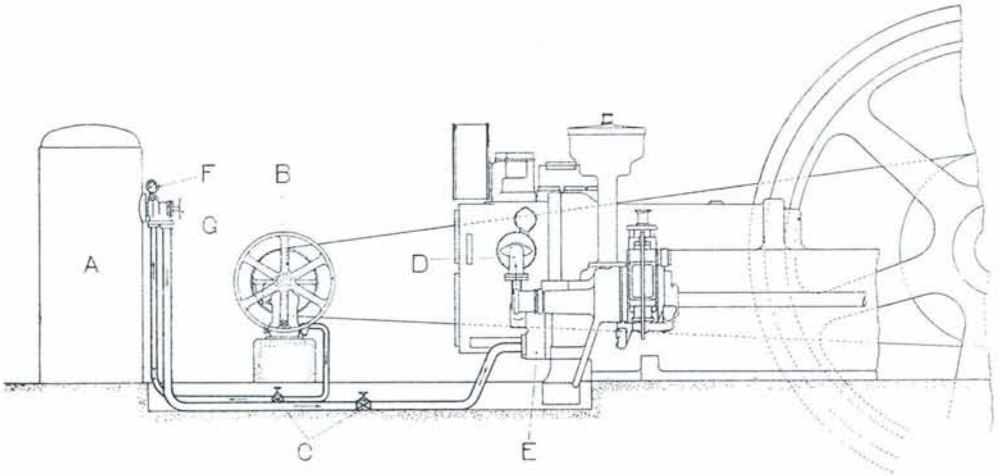
114. **FLYWHEEL KEYS.**—It is important that the keys be driven up tight and kept tight. A slack key, if not attended to, will ultimately cause the breakage of either the flywheel or the crankshaft. Do not pack up a slack key with shims, as it is quite impossible to make a satisfactory job. A new key must be fitted carefully.

COMPRESSED AIR STARTING SYSTEM



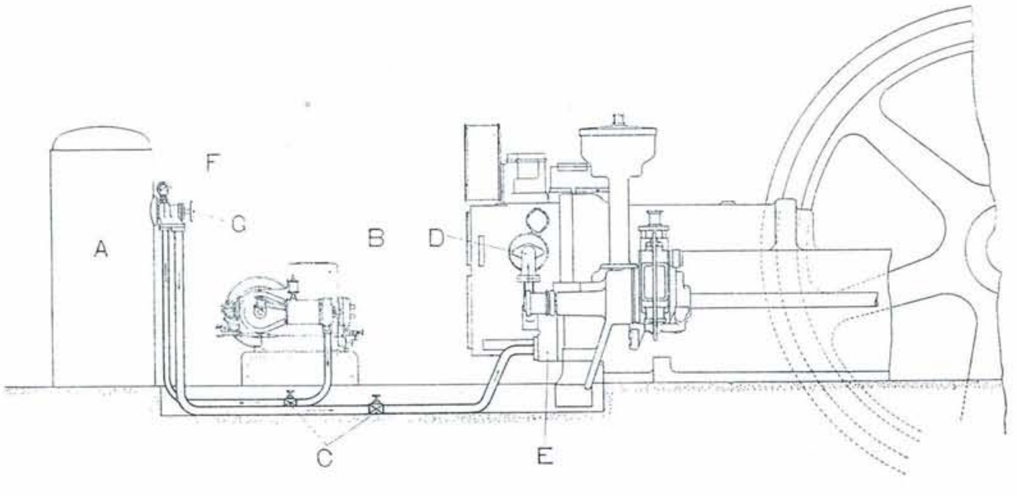
(a) Air receiver
(b) Starter valve
(c) Drain cocks
(d) Stop valve handle
(e) Stop valve

Fig. 58 *Starting apparatus of cam controlled valve, the receiver being re-charged from engine cylinder*



(a) Air receiver
(b) Belt driven air compressor
(c) Drain cocks
(d) Starter valve
(e) Controller valve
(f) Pressure gauge
(g) Stop valve

Fig. 59 *Starting apparatus of automatic type, receiver being charged by belt-driven* ***air compressor***



(a) Air receiver
(b) Motor driven compressor
(c) Drain cocks
(d) Starter valve
(e) Controller valve
(f) Pressure gauge
(g) Stop valve

Fig. 60 *Starting apparatus of automatic type, receiver being charged by independent engine and compressor*

115. **STARTING APPARATUS.**—This consists of an air receiver fitted with stop valve, relief valve and pressure gauge, and connected by piping to the engine starter valve.

Three methods of applying this system have been adopted:—

(a) Fig. 58, the receiver is charged with compressed air direct from the engine cylinder. The charging and starting valve on the engine is cam controlled.

(b) Fig. 59, the receiver is charged with compressed air direct from a belt-driven air compressor, driven either from the main engine or from a countershaft. After the engine is started the receiver is re-charged with air to the maximum pressure required.

(c) Fig. 60, the apparatus consists of an independent engine and compressor.

116. **CAM CONTROLLED STARTER VALVE.—HD4 to HH7 and IHD4 to IHH7 Engines when fitted**—Fig. 61. This valve is operated by a cam on the sideshaft. Compressed air enters above the non-return valve O, which is operated by the starter lever J, before air can pass through the starter valve A into the engine cylinder.

(*a*) *Starting valve*
(*b*) *Adjusting screw*
(*c*) *Starter lever*
(*d*) *Locknut*
(*e*) *Sideshaft*
(*f*) *Starter cam*
(*g*) *Stop pin*
(*h*) *Spring for catch*
(*j*) *Handle for starting lever*
(*k*) *Spring for starter valve*
(*l*) *Collar*
(*m*) *Charging handle*
(*n*) *Non-return valve cover*
(*o*) *Non-return valve*
(*p*) *Starter valve body*

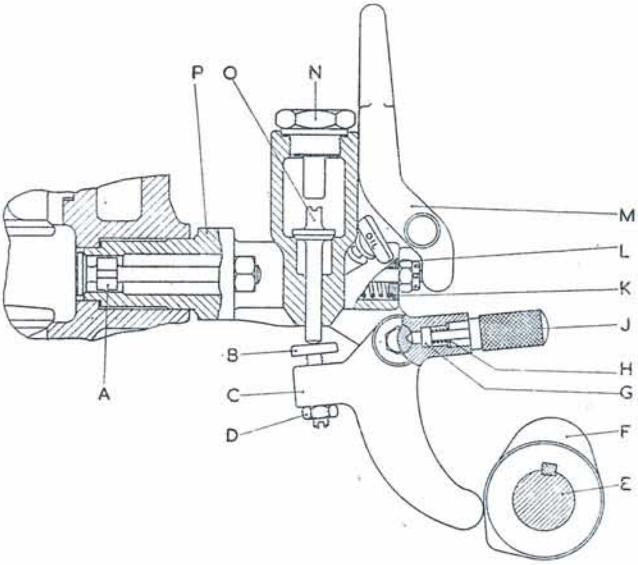


Fig. 61 *Cam controlled starter valve*
HD4 to HH7 and IHD4 to IHH7 Engines

The starter valve handle can be moved into two positions, viz.:—

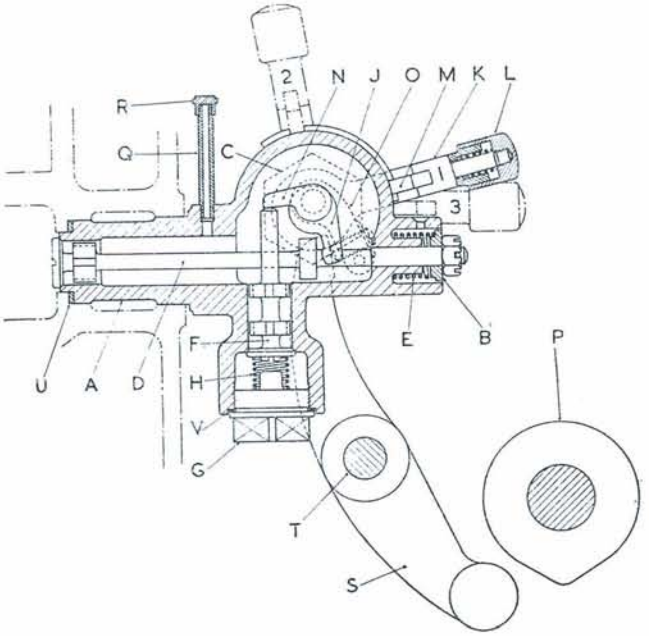
(a) Running position when starter valve A and non-return valve O are closed.

(b) Starting position when the non-return valve can be opened by the cam operated lever C.

The starter valve is lubricated by removing the oil plug in the starter valve casing.

When setting the gear the clearance between the starter lever adjusting screw B and non-return valve O should be $\frac{1}{64}$ inch (0.40 mm.) when the toe of the starter lever C is in contact with the body of the starter cam F.

117. **CAM CONTROLLED STARTER VALVE—HH8 to HH10 and IHH8 to IHH10 Single and Double cylinder Engines.**—Fig. 62.—This valve is operated by the half compression cam on the sideshaft. Compressed air enters below the valve F, which is operated by the action of the levers S, O and N, before the air can pass through the starter valve D into the engine cylinder.



(a)	*Starter valve body*
(b)	*Starter valve spring collar*
(c)	*Operating lever housing*
(d)	*Starter valve*
(e)	*Starter valve spring*
(f)	*Non-return valve*
(g)	*Non-return valve cover*
(h)	*Non-return valve spring*
(j)	*Operating lever for starter valve*
(k)	*Starter valve handle*
(l)	*Starter valve thumb-piece*
(m)	*Pawl for handle*
(n)	*Non-return valve operating lever*
(o)	*Outside operating lever*
(p)	*Half compression cam*
(q)	*Lubricating oil tube*
(r)	*Cap for tube*
(s)	*Starter valve lever*
(t)	*Fulcrum pin*
(u)	*Washer for breech end joint*
(v)	*Washer for valve cover*

Fig. 62 *Cam controlled starter valve HH8 to HH10 and IHH8 to IHH10 Engines*

The handle K can be moved into three positions, viz.:—

1. Running position when valves D and F are closed.
2. Starting position when valve F can be opened by the cam operated levers.
3. Charging position when valve D is held open, and valve F is free to lift, to permit the air in the cylinder to pass into the receiver.

The starter valve opens on the inner dead centre and closes approximately 70 crankshaft degrees before the outer dead centre.

The correct procedure for setting the cam controlled starter valve is:—

(a) Place the crankshaft on the inner dead centre on the power stroke, that is, when all valves are closed.

(b) The starter valve handle K must now be placed in the No. 2 position or starting notch.

(c) With the starter valve handle in the starting position, adjust the outside operating lever screw until the end just touches the starter valve lever S. When correctly set lock the adjusting screw firmly in position.

(d) Rotate the crankshaft until the toe of the starter valve lever S is on the nose of the half compression cam P. In this position there should be at least $\frac{1}{32}$ inch (0.8 mm.) clearance between the outside operating screw and the top of the starter valve S.

In the maximum position of the half compression cam P or starter valve lever S there must be a clearance between the non-return valve F and the cover G, and if this clearance is not obtainable after attending to items (a) and (d) inclusive, then the stop on the cover G must be altered to give the requisite clearance.

118. CAM CONTROLLED STARTER VALVE.—HH11 to HH14 and IHH11 to IHH14 Single and Double cylinder Engines.

—Fig. 63. The valve body A is fitted under the cams. Its function is to control the admission of compressed air to the starting valve in the breech end. A cam operates the lever B which in turn opens the valve C. When not in use, the valve falls off its seat away from the cam. When compressed air is turned on it pushes the valve upwards until the cam comes round and forces the valve off its seat and admits the air to the cylinder.

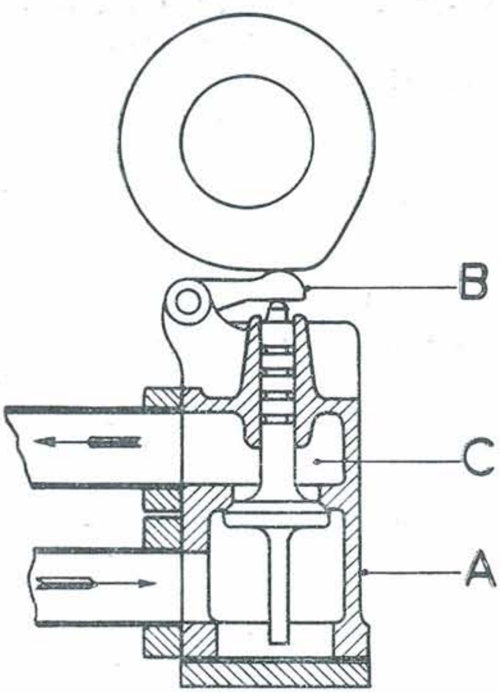


Fig. 63 *Cam controlled starter valve*

(a) Valve body *(b) Starter valve lever*
(c) Starter valve

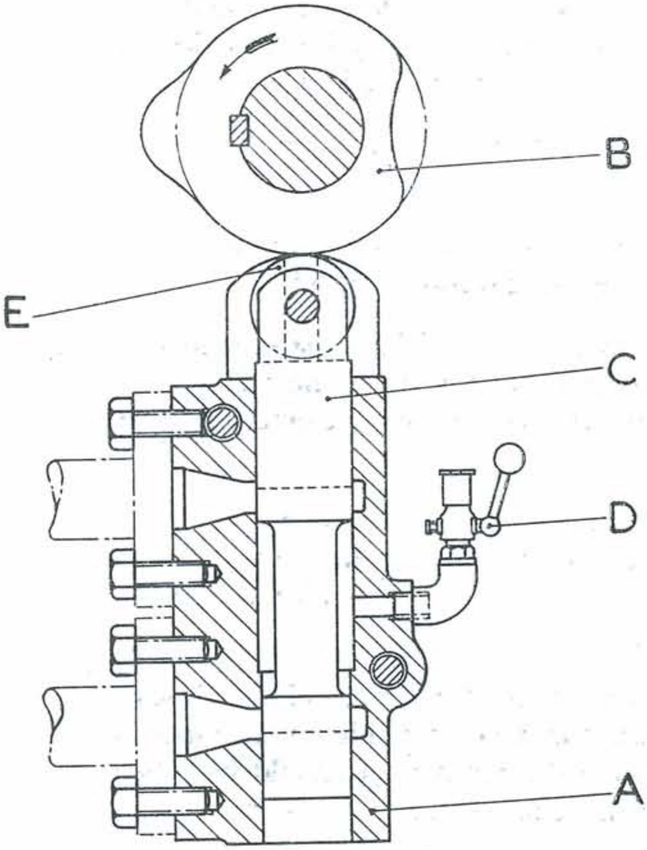


Fig. 64 *Controller valve*
Double cylinder monobloc engines only

(a) Valve body *(d) Lubricator*
(b) Cam *(e) Roller*
(c) Plunger

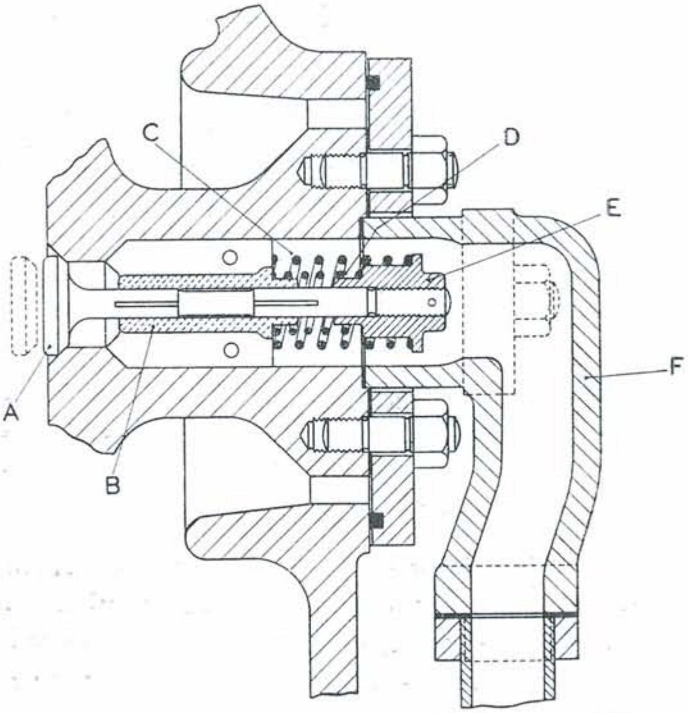


Fig. 65 *Automatic compressed air starter valve HH11 to HH14 and IHH11 to IHH14 and Monobloc Engines*

(a) Starter valve *(d) Liner spring*
(b) Valve guide *(e) Spring cap*
(c) Outer spring *(f) Casing*

119. **CAM CONTROLLED STARTER VALVE.—Double cylinder monoblc engines.** Fig. 64.—The valve body A is fitted under the cam B. Its function is to control the admission of compressed air to the starting valve in the breech end. A cam operates the plunger C, which in turn admits air to the appropriate starter valve. When not in use the valve falls off its seat away from the cam. When compressed air is turned on it pushes the valve upwards until the cam comes round and forces the valve off its seat and admits the air to the cylinder.

120. **AUTOMATIC COMPRESSED AIR STARTER VALVE.—HH11 to HH14 and IHH11 to IHH14 and Monobloc engines.**— Fig. 65.—The automatic valve A is opened by the incoming air from the controller valve, Fig. 64. The springs C and D return the valve to its seat on the supply of air being cut off.

On earlier type engines the compressed air starter valve was operated by a handwheel. By turning the handwheel in a clockwise direction the valve is free to open to admit air. When turned anti-clockwise and screwed firmly on to its seat it prevents any air entering.

121. **AIR RECEIVERS AND VALVES.**—Joints, valve seats, valves and pipes must be maintained in perfect order. A loss of pressure of, say, 20 p.s.i. (1.4 kg. per cm.^{2}) may be expected, owing to the cooling of the air but if the pressure decreases to any extent the receiver should be examined and the leakage located. Only skilled mechanics should be entrusted with the work of remedying any leakage. Leakage from riveted joints can only be remedied by caulking up the seams. Pipe joints should be re-made with red or white lead paste.

Every **200 hours** the drain plug in the receiver should be opened to permit oil and condensation to be blown out.

(a) **Leakage.**—One method of detecting leakage is to pour a little thin oil over all suspected joints; if faulty, air bubbles will be clearly visible rising through the oil.

(b) **Valve Seatings.**—These must be kept carefully ground in. Coarse emery or carborundum must **not** be used. The grinding-in must be finished off with fine rotten stone powder, or fine crocus powder so as to remove any scratches made by the fine emery powder and leave a perfectly smooth surface.

(c) **Inside of Pipes.**—Scale or dirt may be a source of trouble, as loose bits of scale or dirt may get between the valve seatings and damage them. The best plan is to thoroughly hammer the pipes before erection to dislodge any scale and to paint them **inside** to prevent rusting or further scale formation.

(d) **Inside of Receiver.**—Scale or dirt can be a source of trouble, and if such scale or dirt is found and cannot be traced to any other source, it may be advisable for the pipes to be disconnected, and a gallon of lead paint poured inside the receiver; it should be rolled slowly backward and forwards to ensure the whole shell being coated. The surplus paint then being drained out.

(f) **Joints.—Take care of joints which can possibly cause loss of air pressure by leakage in the air system.**

(g) **Receiver Stop Valves.**—Figs 66 and 67.—The stop valve fitted to the bottle type air receiver, Fig. 58, is usually of the design shown in Fig. 66.

The valve body has a gland nut, distance piece, and soft packing to prevent any leakage of air when open. The valve C is opened and closed by the screwed plug B, operated by handle F. An outlet flange G is provided.

The stop valve used on the vertical riveted type air receiver is shown in Fig. 67. Air enters through the valve K when the main valve B is open; the auxiliary valve G being closed to prevent loss of air through the pipe connected to the engine. The relief valve N allows the air to escape should it exceed the stated pressure. When the receiver is charged the valve B is closed. When starting, the auxiliary valve G is first fully opened, and then the main valve B is opened to permit the air to pass to the engine.

122. **COMPRESSED AIR PIPES.**—All pipes should be fitted with drains at the lowest point and drained every **200 hours,** or more frequently if necessary. Pipes should be so arranged that no condensation drains into air receivers, compressor, and into the pipe leading to the air master valve.

123. **AUXILIARY AIR COMPRESSOR SETS.**—Separate instructions are issued for the working and maintenance of the auxiliary air compressor set.

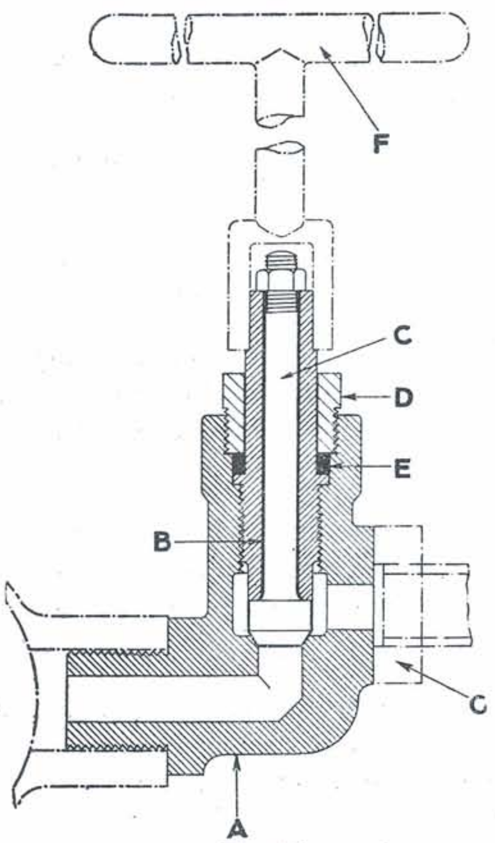


Fig. 66

(*a*) *Stop valve body*
(*b*) *Screwed plug*
(*c*) *Valve*
(*d*) *Gland nut*
(*e*) *Distance piece*
(*f*) *Handle*
(*g*) *Outlet flange*

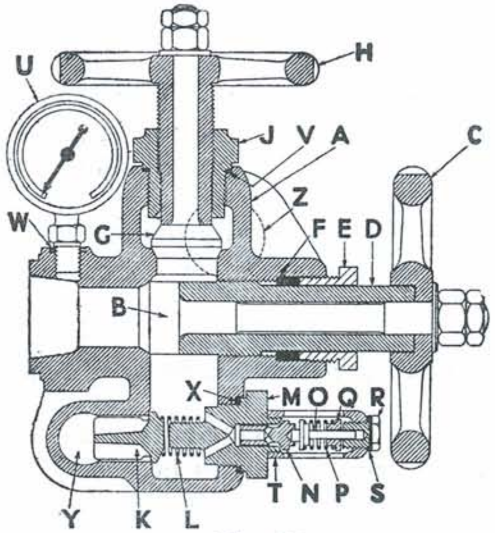


Fig. 67

(*a*) *Receiver valve body*
(*b*) *Main valve*
(*c*) *Main handwheel*
(*d*) *Handwheel guide*
(*e*) *Gland nut*
(*f*) *Gland ring*
(*g*) *Auxiliary valve*
(*h*) *Auxiliary valve wheel*
(*j*) *Auxiliary valve guide*
(*k*) *Automatic valve*
(*l*) *Automatic valve spring*
(*m*) *Relief valve guide*
(*n*) *Relief valve*
(*o*) *Relief valve spindle*
(*p*) *Relief valve spring*
(*q*) *Relief valve spring collar*
(*r*) *Relief valve adjusting screw*
(*s*) *Relief valve ferrule*
(*t*) *Relief valve body*
(*u*) *Pressure gauge*
(*v*) *Washer for guide*
(*w*) *Washer for guide gauge*
(*x*) *Washer for guide relief valve body*
(*y*) *Inlet from compressor*
(*z*) *Outlet to engine*

LUBRICATING OIL SYSTEMS

124. **LUBRICATION.**—All engines have forced lubrication to the cylinder, and connecting rod large-end bearing ring lubricator, also to the piston pin and exhaust valve on medium and larger engines.

Lubricating oil should be passed through fine strainers before being poured into the lubricators to prevent any foreign matter entering the oil system. Lubricating oils used on engines working on heavy or asphaltic fuels should be renewed more frequently, since the lubricant quickly becomes contaminated.

Many engines have been seriously injured by the use of totally unsuitable oil, and unless the lubricant used is supplied by, or approved by us our guarantee is not operative.

Our recommendations are:—

IHD4 to IHH10 Engines.
Cylinder and Bearing lubrication *Crossley* **"O"** brand (S.A.E.20 specification)

IHH11 to IHH14 also Double Cylinder Monobloc Engines.
Cylinder and Bearing lubrication *Crossley* **"V"** brand (S.A.E.30 specification)

HD4 to HH14 Single and Double Cylinder Engines.
Cylinder and Bearing lubrication *Crossley* **"O"** brand (S.A.E.20 specification)

Governor Dashpot.
Reservoir *Crossley* **"H"** *or* **"V"** brand (S.A.E.30 specification)

Air Compressor Sets.
General lubrication *Crossley* **"H"** *or* **"V"** brand (S.A.E.30 specification

In tropical climates or hot engine-rooms the more viscous straight mineral *Crossley* "*V*" brand may be used as a single purpose lubricant. "O" brand is prefered on the smaller engines for cylinder and piston lubrication since this grade is of the compounded oil type.

On earlier engines the oil recommendations are given on the lubrication instruction plate attached to the engine but the above recommendations generally apply.

Crossley "*H*" brand is a straight mineral oil suitable for bearing lubrication and for such applications can be employed in lieu of "O" brand. It is **not recommended** for the cylinder lubrication.

In tropical climates, *Crossley* "*IH*" brand which is a straight mineral oil to S.A.E. 40 specification can be used in place of "H" brand for bearing lubrication only.

Crossley oils can be obtained in drums or casks, and we supply these oils to foreign ports. **Their use can be regarded as an insurance on the good working of the engine.**

The feed rates and the quantity of oil used are given in paragraph 126.

125. **MECHANICAL LUBRICATOR.**—Fig. 68.—The sight feed glasses G should be filled with **a saturated solution of salt** (specific gravity 1.20 to 1.22), that is, water in which a quantity of salt has been well mixed and then allowed to settle for several hours, the water above the deposit being then carefully drawn off and poured into the glasses. The oil drops will rise through this solution more quickly than through ordinary water, and the glass will remain cleaner inside. The salt also tends to prevent freezing of the water in cold climates.

Glycerine may be used as an alternative to the salt solution.

When distilled water, or a weak salt solution is used, the oil drop size is larger with a corresponding increase in lubricating oil consumption. With lubricants containing detergent additives distilled water must be used in the sight feed glasses.

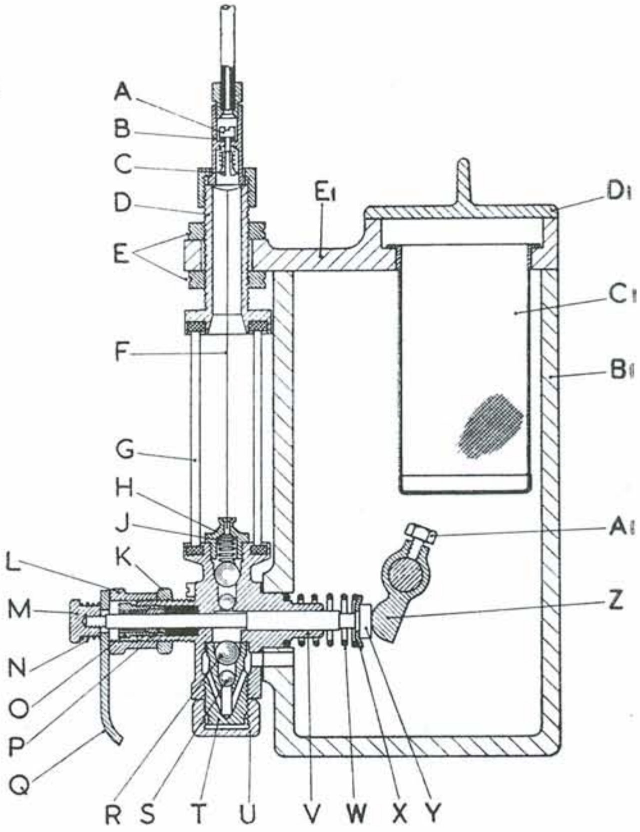


Fig. 68 *Mechanical lubricator—T. and K. design*

(*a*) *Non-return valve*
(*b*) *Tail pipe*
(*c*) *Spring retainer*
(*d*) *Holder for sight feed glass*
(*e*) *Locknut*
(*f*) *Guide wire*
(*g*) *Sight feed glass*
(*h*) *Oil nipple*
(*j*) *Spring for delivery ball valve*
(*k*) *Locknut*
(*l*) *Adjusting sleeve*
(*m*) *Thumb nut*
(*n*) *Spring for trigger*
(*o*) *Gland*
(*p*) *Floating bush*
(*q*) *Trigger*
(*r*) *Large ball valve*
(*s*) *Small ball valve*
(*t*) *Suction valve cage*
(*u*) *Nut*
(*v*) *Pump body*
(*w*) *Plunger spring*
(*x*) *Collar*
(*y*) *Plunger*
(*z*) *Tappet*
(*a1*) *Screw for tappet*
(*b1*) *Container*
(*c1*) *Strainer*
(*d1*) *Strainer cover*
(*e1*) *Cover for container*

Fill the container B_1 with lubricating oil, loosen the coupling nuts on the far end of the delivery pipes, securing the nuts at the pump end only. Open the air vent in the pump body a couple of turns, and work the pump by hand until the oil flows freely from the air vent, indicating that all air has been expelled from the pump. Then screw up the air vent tightly and continue pumping by hand till oil appears at each coupling, all of which can then be connected up, making thoroughly tight joints. The lubricator will then begin to feed oil as soon as the engine starts.

The stroke of each pump is adjustable and regulated by altering the position of the adjusting sleeve L and locknut K; after determining the necessary position, this sleeve and nut must be locked one against the other. The priming lever on each plunger end allows a few extra strokes to be given by hand, without stopping the engine or altering the rate of feed. The priming rod allows all the feeds to be operated by hand at the same time.

Periodically examine suction and delivery ball valves. Rusted or pitted valves must be replaced.

Use of Air Vent.—Should the lubricator be accidentally allowed to empty, possibly admitting air to the pump, the air vent should be again used in the manner described above.

To Clear or Renew a Sight Feed Glass.—Uncouple the union nut and remove the guide wire F and slack off the milled nuts E on the shank D. The shank can then be lifted and the glass removed.

To Re-fill a Sight Feed Glass.—Uncouple the union nut and remove the guide wire. See that the sight feed glass G and the shanks are thoroughly free from oil on the inside. Then fill it with a saturated solution of salt to the top of D, and replace the guide wire.

Plunger Packing Gland.—A spanner is provided to tighten up the plunger packings The plunger Y should be put on its extreme inward position and the parts L and K slacked back to allow a spanner to be used on the hexagon packing screw. The lubricators are sent out with this packing properly adjusted, and this should not require attention for a considerable time. Do not screw up too tightly.

Inspection of Suction Valves.—Remove the milled cap U and unscrew the suction cage T. The suction valves are then accessible for examination. Screw the cage T up tightly after replacing.

Inspection of Delivery Valves.—After removing the sight feed glasses, the nozzle H may be unscrewed to enable the delivery valves to be accessible.

In the event of a lubricator not feeding, open the air vent and see that oil comes out when flushing by the trigger Q. If the lubricator still does not feed, unscrew the suction cap U and cage T, clean the suction valves R and S, screw the cage T home tightly, and the lubricator should then feed properly.

Where there is a tendency for streaming to occur in the sight feed glasses, then this problem can be solved by cutting short the guide wire. The wire should terminate just above the oil globule prior to its release from the feed nozzle.

126. **QUANTITY OF LUBRICATING OIL.**—It is not possible to define the exact quantity of oil to use, as much depends on the fuel used, the average load, and the condition of the engine; the table shows the lubricator **feed rates** and the approximate **amount required per cylinder** under good working conditions. On new engines it is advisable to increase the feed rates and gradually cut down to the recommended quantity.

The total amount of lubricating oil per hour approximately corresponds to the number of drops per minute recommended when using a **saturated salt solution** in the sight feed glasses and under temperate atmospherical conditions.

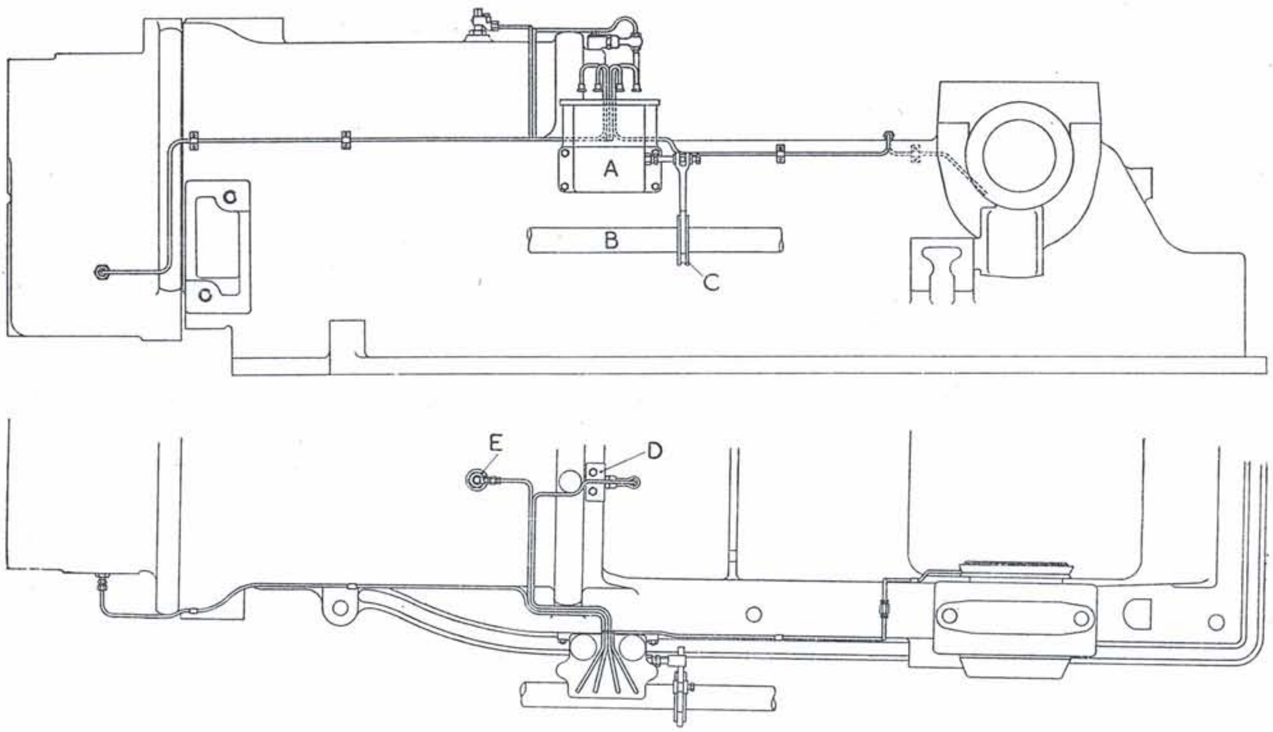


Fig. 69 *Lubricating system for single and double cylinder medium and larger size engines*

(*a*) *Mechanical lubricator*
(*b*) *Sideshaft*
(*c*) *Lubricator driving eccentric*
(*d*) *Oil pipe and wick connection for connecting rod small-end bearing*
(*e*) *Cylinder liner oil tube connection*

IHD and IHH engines

Size of Engine	IHD4	IHD and IHH6	IHH7	IHH8	IHH9	IHH10	IHH11 and 2IHH11	IHH12 and 2IHH12	IHH14 and 2IHH14
Cylinder and Piston	12	15	17	15	17	21	15	18	21
Exhaust Valve	—	—	—	1	1	1	1	1	1
Connecting Rod Large-end Bearing	6	7	8	8	9	10	10	12	16
Connecting Rod Small-end Bearing	—	—	—	—	—	—	6	7	8
Lubricating Oil Consumption per Hour	0·240 lbs (0·109 kgs)	0·290 lbs (0·132 kgs)	0·340 lbs (0·154 kgs)	0·320 lbs (0·145 kgs)	0·360 lbs (0·163 kgs)	0·430 lbs (0·195 kgs)	0·430 lbs (0·195 kgs)	0·508 lbs (0·230 kgs)	0·615 lbs (0·278 kgs)

HD and HH engines

Size of Engine	HD4	HD and HH6	HD and HH7	HD8, HH8 and 2HH8	HD9, HH9 and 2HH9	HD10, HH10 and 2HH10	HD11, HH11 and 2HH11	HD12, HH12 and 2HH12	HD14, HH14 and 2HH14
Cylinder and Piston	8	10	11	10	11	14	10	12	14
Exhaust Valve	—	—	—	1	1	1	1	1	1
Connecting Rod Large-end Bearing	6	7	8	8	9	10	10	12	16
Connecting Rod Small-end Bearing	—	—	—	—	—	—	6	7	8
Lubricating Oil Consumption per Hour	0·15 lbs (0·068 kgs)	0·195 lbs (0·089 kgs)	0·255 lbs (0·116 kgs)	0·255 lbs (0·116 kgs)	0·280 lbs (0·127 kgs)	0·340 lbs (0·154 kgs)	0·360 lbs (0·163 kgs)	0·430 lbs (0·195 kgs)	0·530 lbs (0·240 kgs)

The air valve is lubricated independently with Crossley "O" brand from a small lubricator A, Fig 52, on the air valve block cover; so also is the exhaust valve on the smaller engines from a small lubricator Q, Fig. 52, attached to the breech end.

127. **LUBRICATING OIL FILTER.**—*Filter all lubricating oil before using.* We recommend the use of a filter, by which all lubricating oil may be filtered and used again, except that coming away from the cylinder.

The oil which drips from the mouth of the cylinder can be drained from a pipe at the side of the bedframe. This must not be used again on the engine as its lubricating qualities have been impaired. All lubricating oil should be completely free from all foreign matter, metal dust, water, etc.

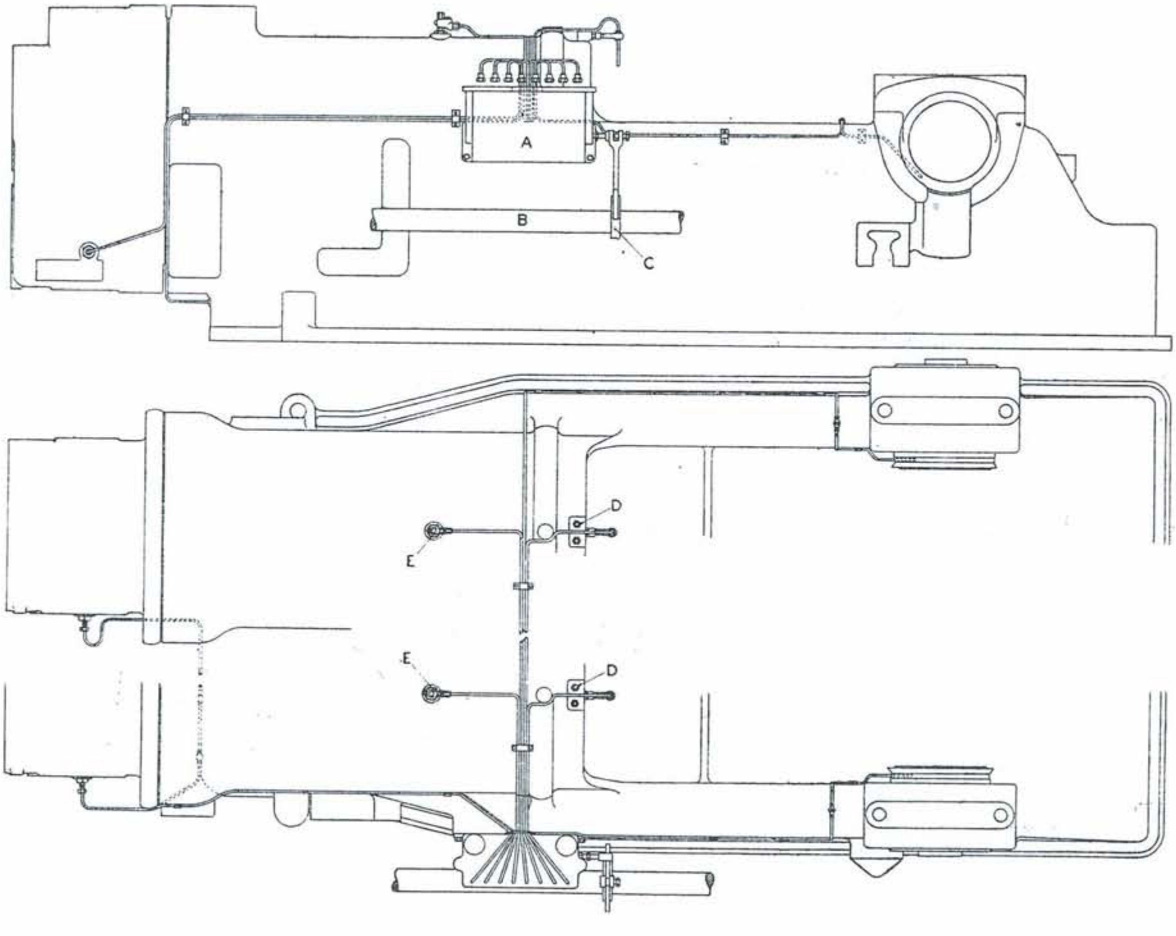


Fig. 70 *Lubricating system for double cylinder monobloc engines*

(*a*) *Mechanical lubricator*
(*b*) *Sideshaft*
(*c*) *Lubricator driving eccentric*
(*d*) *Oil pipe and wick connection for connecting rod small-end bearing lubricator connection*
(*e*) *Cylinder liner oil tube connection*

DISMANTLING

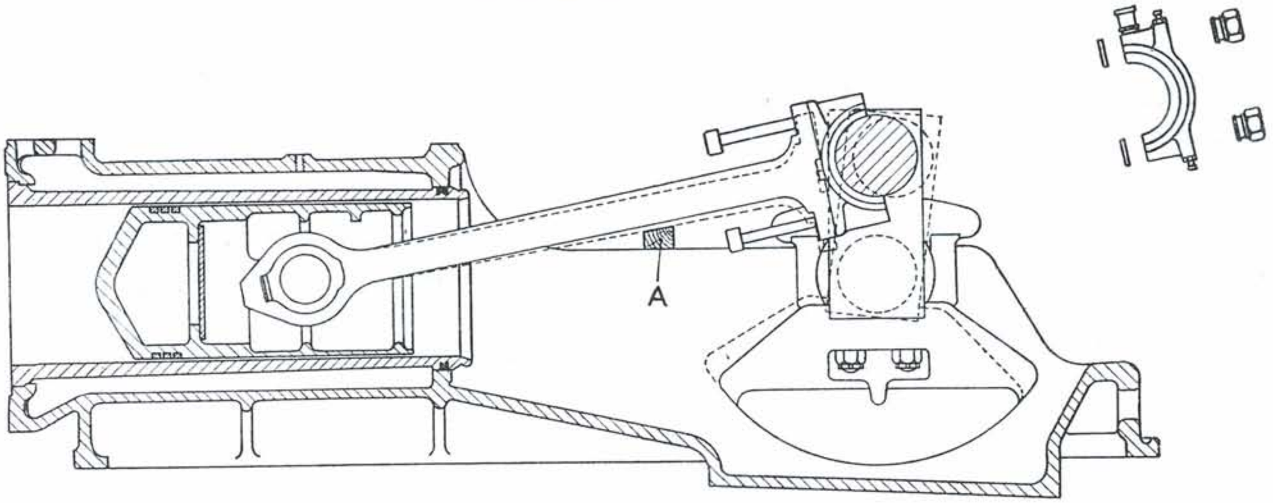


Fig. 71

128. TO WITHDRAW A PISTON—

(a) Place the crankshaft in the vertical position with the balance weights underneath as shown in Fig. 71.

(b) Place a piece of timber A across the top of the bedframe underneath the connecting rod in such a position that the balance weights will swing clear. This timber must be about 0.375 in. (10 mm.) to 0.5 in. (12 mm.) clear of the rod.

(c) Move the connecting rod cap and front half of the bearing, and tap the bolts back clear of the rod to avoid injury of the crankpin by the bolts.

(d) Remove the crankshaft forward a little, until the back half bearing round the journal can be withdrawn.

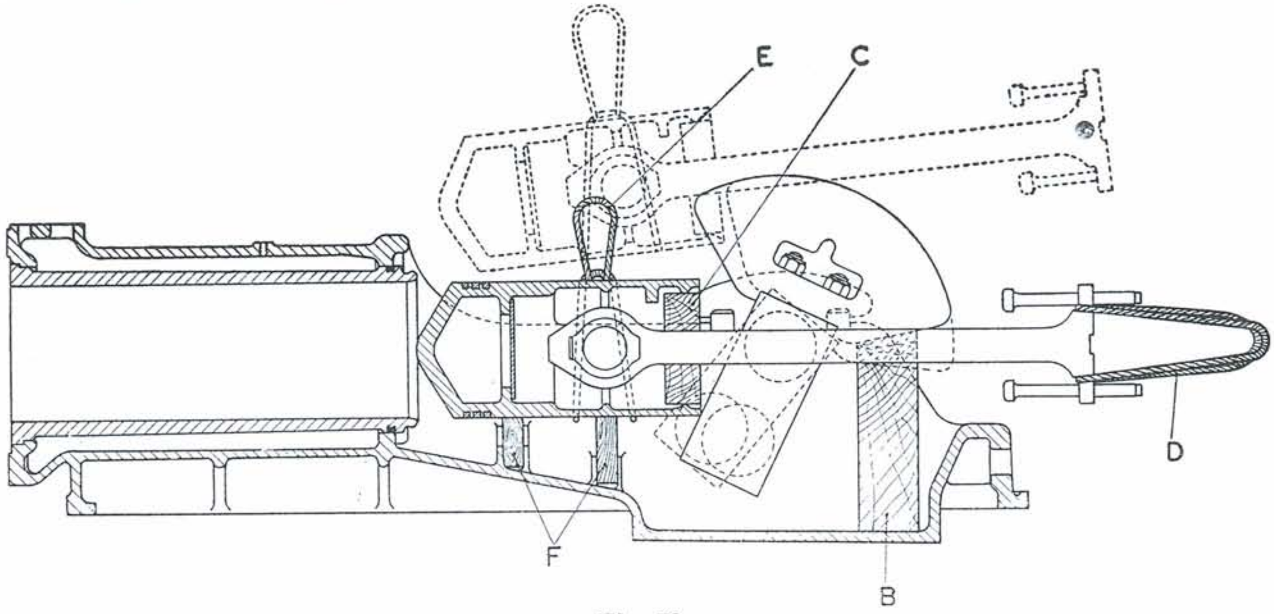


Fig. 72

(e) Move the crank further forward until the large-end is quite free and the rod rests on the piece of timber A.

(f) Bring the balance weights into their top position, Fig. 72, and prop them up with wood B placed between them and the bottom of the bed.

(g) Lower the rod end until it is in line with the centre line of the piston, and pack the rod in this position by placing pieces of wood C inside the piston at both top and bottom.

(h) Pass a rope sling D round the large-end and bring the sling forward between the balance weights so that a lever may be inserted in the loop. Then pull the piston out of the liner until the first ring appears.

(i) Pass another sling E around the body of the piston and attach it to pulley blocks, fixed overhead, and arranged so that the pull will be slightly forward as well as slightly upward.

(j) Pull the piston forward until any further movement is prevented by the crankshaft or weights.

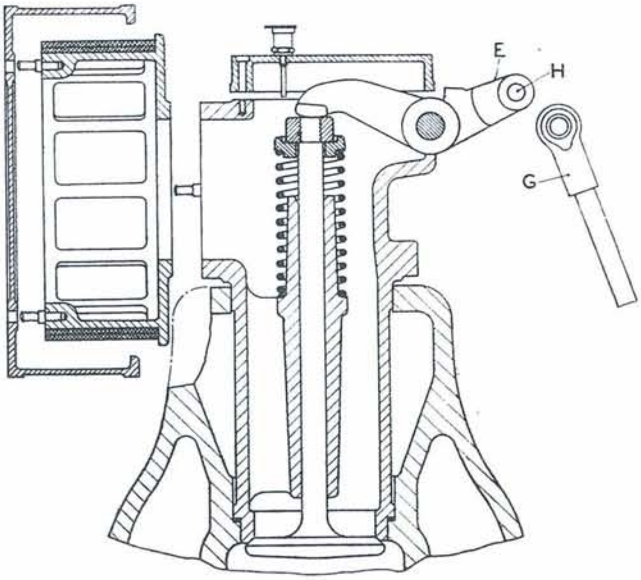


Fig. 73

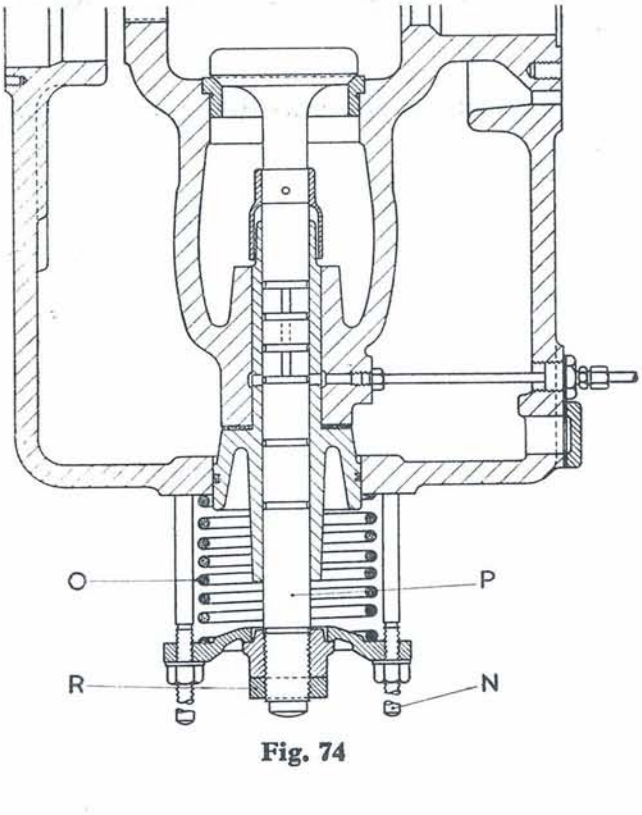


Fig. 74

(k) Remove the block B from the bedframe, turn the flywheel forwards slowly until the crankshaft is in the dotted line position, Fig. 72. Then hoist the piston upwards by the pulley blocks, into the upper position shown.

On larger engines, ribs are provided inside the bedframe to receive pieces of timber F so that when the piston is withdrawn it may rest upon them.

129. TO REMOVE THE AIR VALVE BODY. Fig. 73.

(a) Remove the air silencer from the body.

(b) Uncouple the rod G from the lever E by taking out the pin H.

(c) The valve and body can then be withdrawn.

130. TO REMOVE THE EXHAUST VALVE. Fig. 74.

(a) Screw the studs N into the holes provided in the underside of the breech end.

(b) Screw nuts on these studs until the pressure of the spring O is taken off the valve P.

(c) Unscrew the nuts at R and draw the valve out upwards by the grinding handle.

131. TO REMOVE THE EXHAUST VALVE SPRING. Fig. 74.

(a) Remove the exhaust valve as described in paragraph 130 and remove the exhaust lever.

(b) Unscrew the nuts on the long studs N and remove the spring.

INSTRUCTIONS FOR WORKING WITH HEAVY AND VISCOUS FUELS

132. These fuels are very dirty and contain many impurities It is necessary to filter all the fuel before entering the tank, otherwise the strainers on the suction side of the fuel pump will become choked; this is particularly necessary with viscous fuels. Foreign matter in the fuel will result in faulty spraying, imperfect combustion and rapid wear of the working parts.

With heavy and asphaltic fuels it is necessary to fit "Vicol Parts" consisting of a heater, with regulator valves H, attached to the exhaust pipe; the extra heat available enables the fuel to become sufficiently fluid to be sprayed efficiently.

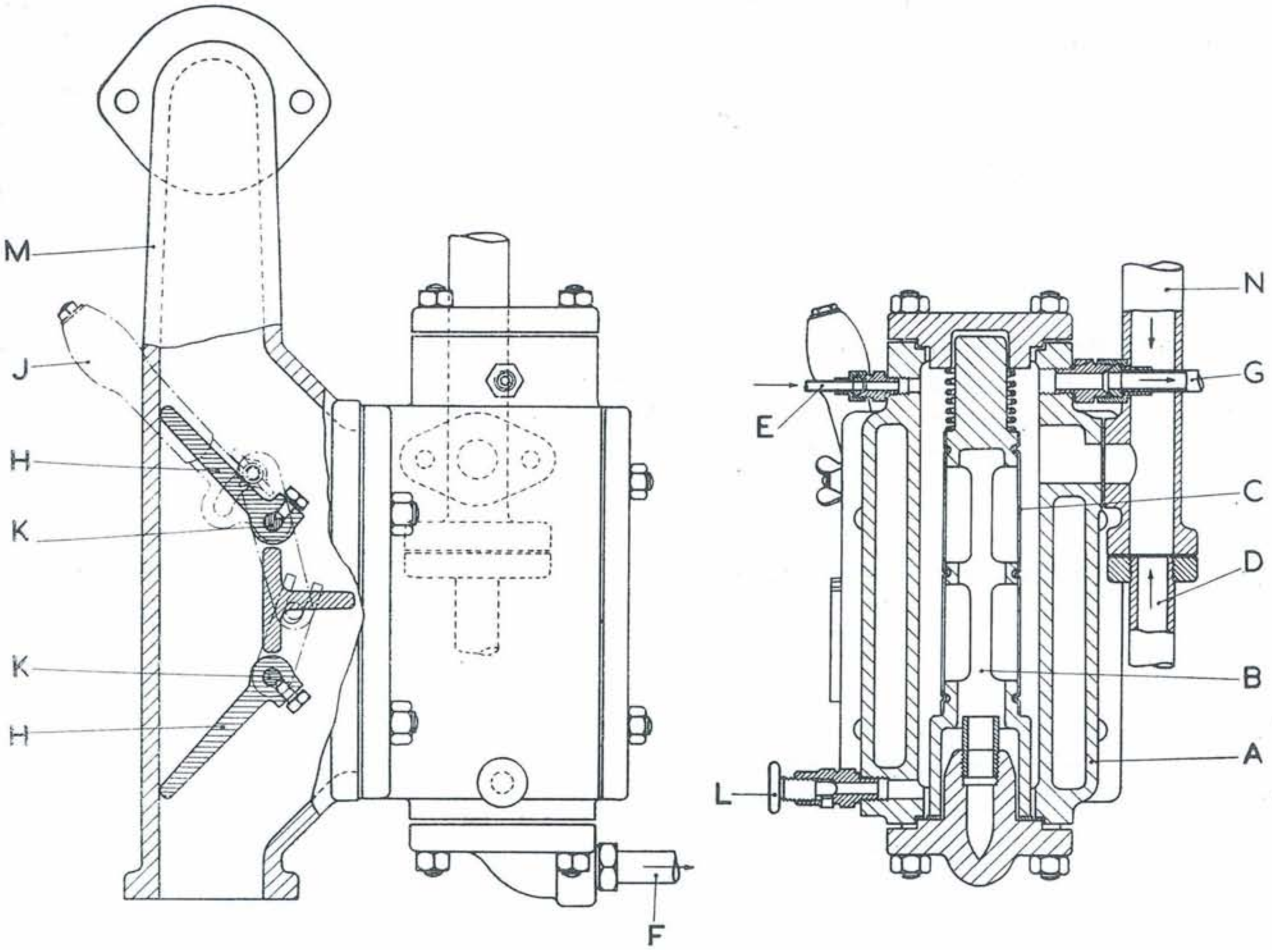


Fig. 75 *Fuel heater for viscous fuels*

(*a*) *Oil heater body*
(*b*) *Strainer plug*
(*c*) *Strainer gauge*
(*d*) *Inlet pipe from fuel tank*
(*e*) *Pipe from refined fuel tank*
(*f*) *Outlet pipe to fuel pump*
(*g*) *Vent pipe to overflow tundish*

(*h*) *Regulator valves*
(*j*) *Handle for valves*
(*k*) *Spindle for valves*
(*l*) *Drain cock*
(*m*) *Exhaust pipe*
(*n*) *Return pipe from overflow tundish*

Proceed as follows :—

(a) **The engine must be started on a free flowing fuel, such as gas oil,** therefore open the cock on the refined oil tank and close the cock on the fuel tank.

(b) Open the exhaust regulator valve by moving the handle J to the maximum left position, i.e., away from the sideshaft.

(c) When the "Preparing to Start" instructions, paragraphs 32 and 33, have been attended to the engine should be started as directed in paragraph 34.

(d) Continue running until the temperature registered by the fuel pump thermometer is at least 95° to 100°F. (35° to 38°C.). A thermometer must be placed and retained in the fuel pump pocket provided for the purpose.

(e) Close the starting oil tank cock and change over to the viscous fuel by opening the fuel tank cock.

When the temperature increases to 150° or 170°F. (66° to 77°C.) the handle J should be partly closed so that the temperature is maintained between these limits. The correct position of the handle is dependent upon the viscosity of the fuel and the power developed by the engine.

133. **STOPPING.**—Change over from the viscous fuel to the refined oil for about twenty minutes prior to shutting down. Only thin fuel should remain in the fuel system when the engine is stationary otherwise the engine will not re-start easily and cold viscous fuel is not easily pumped or efficiently atomised.

134. **FUEL STRAINER.**—Strainers should be examined and cleaned at least every **50 hours.** The gauze C should be examined and if damaged it must be replaced.

135. **FUEL PUMP CAM.**—The fuel pump discs of engines tested at the works with "Vicol Parts" are drilled in two places, and the steady pin holes are marked "heavy" and "light"; the steady pin L, Fig. 41, will be found in the hole marked "heavy". When the use of viscous fuel is discontinued, the disc should be reset, and the steady pin inserted in the hole marked "light."

136. **VISCOSITY OF FUEL.**—Unless the fuel is sufficiently fluid it will not run freely from the tank to the engine, and with very viscous fuels it may be necessary to add from 15 to 25 per cent of gas oil to enable them to flow freely.

WARNING.—Do not change over to the more viscous fuel before the temperature of the fuel pump has risen sufficiently.

INSPECTION CHART.

137. **Based on Engine working 50 hours per week.**

It should be noted that the amount of maintenance and overhauling varies according to the duty the engine is to perform and the quality of fuel and lubricating oil employed.

PERIOD	ITEM	INSTRUCTION	Paragraphs
DAILY	Engine house	Keep free from dirt, and have spare parts and tools handy	24
	Fuel	Maintain adequate supply	42, 132
	Lubricating oil	Maintain adequate supply of brand recommended	124, 126
	Fuel system	Stop any leaks and drain off any water	43,45,50,51, 52,53,64,69, [70, 75
	Lubricating oil system	Examine oil levels and points for lubrication. See that oil feeds are functioning	53, 98, 106, 108, 125
	Bearings	Be satisfied all run cool and oiling rings rotating	106, 107
	Water supply	To be clean and not hard, so as to avoid deposit	13, 14
	Piston	Examine for clean running	102, 104, 105
	Stopping	Leave engine in condition for starting	38, 39
	Minor points	Give prompt attention to any that arise	23, 24
	Compressed air	Maintain correct air pressure	36, 121
	Air and exhaust valves	Fill lubricators	98
	Bedframe	Clean out oil groove round bedframe	5
WEEKLY	All fuel and lubricating oil strainers	Clean free from any obstruction	43, 45, 125 127, 134
	Fuel tank and strainers	Drain off any water if heavy oil is used; clean strainers	43
	Control valve	Be sure that no leakage is occurring	64
	Ignition tube	Clean out if heavy oil is used	98
MONTHLY	Pecker bolt clearance	Verify amount as per instructions	65 92
	Clearance between cams and rollers	Verify amount as per instructions	110
	Air silencer matting or gauze	Clean and free from obstruction	97
	Exhaust valve	Remove and clean. Keep seating in good condition	98
	Fuel sprayer and strainer	Take out and operate spray. See that it does not dribble. Clean strainer	69, 70, 72
	Fuel strainer or heater	Examine heater and clean strainer	45
	Fuel and lubricating oils	Keep adequate supplies in stock	124, 126
	Air receiver and pipes	Drain condensate from receivers and pipes	121, 122
	Fuel pump	Test pump by " blanking " delivery. See that pump is " solid " when pumped by hand	61

INSPECTION CHART—continued

PERIOD	ITEM	INSTRUCTION	Paragraphs
THREE MONTHS	Cylinder and breech end	Remove any deposit	98
	Exhaust pipe and silencer	Scrape out any carbon	16
	Air, exhaust, starting air and receiver valves	Remove and clean. Keep seatings in good condition	98, 116, 117 120, 121
	Cylinder and breech end	Examine for deposit if water is hard	14, 98, 102
	Bedframe crankrace	Remove dirt and sediment	127
	Fuel strainer or heater	Examine container and strainer for condition	45
	Starter valve gear	Check adjustments	116, 117, 119 120
SIX MONTHS	Fuel pump valves	Verify lift and keep seating in good condition	50, 51, 52, 53
	Main bearings	Examine for wear	29, 106, 107, [108
	Connecting rod bearings and bolts	Examine bearings and bolts for distortion	109
	All keys and fastenings	See if secure throughout	111, 114
	Spare parts	Examine and see if sufficient	29
ANNUALLY	Piston, and combustion chamber	Remove piston, and clean	98, 99, 103, [104
	Governor dashpot	Replenish lubricating oil in dashpot	90
	All working parts	Examine all working parts, and replace worn pins or bushes	23, 29
		Overhaul engine generally	26
	Crankshaft system	Check alignment	12
	Oil wells	Clean out and replenish with fresh oil	106
	Maximum cylinder pressures	Check pressures	57
	Exhaust system	Examine for obstructions and clean silencer	16, 18
	Fuel filter	Replace felt pads	47

DIAGNOSIS CHART.

138. **Read this in conjunction with Instruction Book.**

TROUBLE	POSSIBLE CAUSE	REMEDY	Paragraphs
ENGINE WILL NOT START	Fuel turned off or insufficient supply	Examine source of supply	43, 44, 45
	Water in fuel system	Drain off and prime afresh	43
	Air-lock in fuel system	Open relief valve and pump by hand, also open plug on fuel pump suction	45, 60, 69
	Spray holes choked, or leakage	See instructions	69, 70, 72, 73
	Fuel too viscous	Prime with thin fluid oil	42, 45 [75
	Insufficient air pressure	Charge air receiver	115, 121
	Ignition tube choked or not hot enough for lamp starting	Remove obstruction, or heat as required	35, 98
	Governor prop out of action	Put in position	33, 35
ENGINE STOPS SOON AFTER STARTING	Similar to the first six above	Corresponding to above	
	Compression pressure too low	Examine exhaust valve seat and spindle	41, 98
ENGINE RACES	Pecker bolt or control valve clearance too great	Reduce amount. See instructions	50, 64, 65, 92
	Dashpot piston stuck	Thin dashpot oil or use glycerine	90
	Excess fuel in cylinder	Open sprayer relief valve, also exhaust valve	33, 68
	Incorrect adjustment of speeder spring	Alter tension to reduce speed	88, 91
	Control valve sticking		50
ENGINE HUNTS	Air-lock in fuel system	Dislodge air as above	45, 60, 69
	Governor parts not free	Remove springs and locate cause	85 to 92
ENGINE WILL NOT CARRY LOAD	Dirt in sprayer or leakage	See instructions	69 to 75
	Fuel too viscous	Prime with refined oil	42, 45
	Pecker bolt or control valve clearance too little	Increase according to instructions	50, 64, 65, 92
	Sprayer spindle tight	Remove and clean	73, 74
	Half-compression cam in gear	Release the half-compression cam	33
	Control valve leaking	Grind-in lightly	64
	Unsuitable fuel or wrong temperature	Change the fuel or regulate heat	42, 45
	Exhaust pipe or silencer choked	Clean parts affected	16, 18, 41
	Exhaust system incorrect	Check pipe bores and lengths	17
	Air silencer choked	Remove obstruction	97
	Insufficient lubrication	Examine lubricating system	33, 108, 125 to
	Air-lock in fuel system	Dislodge as above	45, 60, 69 [127
	Dirt under fuel pump valves	Clean and grind-in if necessary	58
	Pistons dirty or drying	Clean piston rings, check over exhaust system, examine lubricating system	16, 17, 103, 104, 125to 127
	Cylinder liner worn	Replace liners	102
	Piston ring stuck	Replace worn liners, change quality of fuel	42, 102, 104

DIAGNOSIS CHART—continued

TROUBLE	POSSIBLE CAUSE	REMEDY	Paragraphs
CARBONISATION OR BAD COMBUSTION	Leaky sprayer or control valve ..	See instructions	68, 75
	Unsuitable fuel or lubricating oil ..	Change the oil. See instructions	42, 124, 126
	Exhaust pipe choked or valve sticking	Dislodge any carbon and examine valve ..	98
	Fuel heater or water too cold ..	Regulate to give higher temperature	15, 45
	Fuel heater too hot	Regulate heat supply	45
	Loss of compression	Examine exhaust valve seat and spindle ..	41, 98
	Late injection of fuel	Alter timing in extreme circumstances only ..	54, 110
	Air-lock or choked vent pipe ..	Dislodge air and clear vent pipe	45, 60, 69
	Sprayer spindle or pump plunger sticking	Examine cup ring and lubricate spindle ..	63, 70, 71
	Exhaust system incorrect	Check system	16, 17
ENGINE KNOCKS	Sprayer spring too tight	Reduce compression of spring	78, 81
	Circulating water too hot or scale formation	Increase water supply or remove scale as necessary	14, 15
	Carbon on piston or breech end	Clean according to instructions	98, 103, 104
	Engine overloaded	Reduce the load	87, 92
	Unsuitable fuel or lubricating oil ..	Change the grade. See specifications ..	42, 125
	Loose flywheel key or connecting rod bearings	Refit or renew as necessary	108, 114
	Gearwheels not deep enough in gear	Adjust with screw	112
	Injection of fuel too early	Alter timing in extreme circumstances only ..	54, 110
ENGINE STOPS SUDDENLY	Failure of fuel supply	Replenish	42, 43
	Piston or connecting rod bearings overheated	Attend to lubrication and water circulation ..	102, 107, 108
	Fuel too hot	Regulate heat supply	42, 45
	Fuel supply restricted due to clogged strainers..	Clean strainers and prime afresh	45

CROSSLEY BROTHERS LIMITED

OPENSHAW :: MANCHESTER 11 :: ENGLAND

Telephone: Manchester EASt 1353 Printed in England *Telegrams:* "Gasengine, Manchester"